



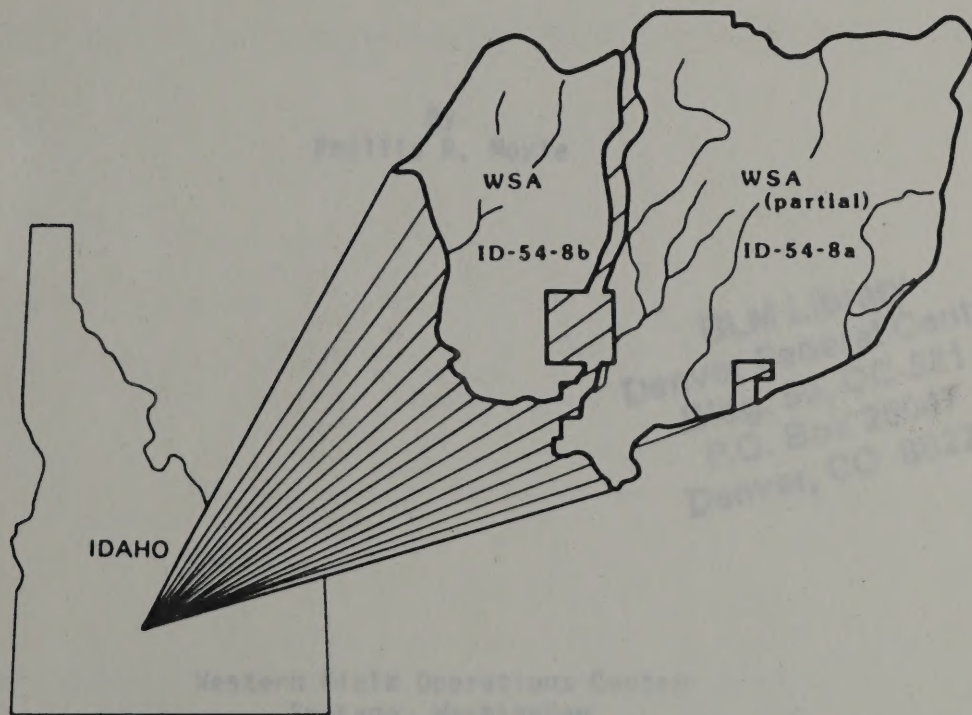
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Bureau of Mines Mineral Land Assessment/1985
Open File Report

Mineral Resources of the Gooding City of Rocks Study Areas, Gooding County, Idaho



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BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR

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PREFACE

The Federal Land Policy and Management Act (Public Law 94-579, October 2, 1976) requires the U.S. Geological Survey and U.S. Bureau of Mines to conduct mineral surveys on U.S. Bureau of Land Management administered land designated as Wilderness Study Areas . . . to determine the mineral values, if any, that may be present . . . Results must be made available to the public and submitted to the President and the Congress. This report presents the results of a Bureau of Mines mineral survey of the

**MINERAL RESOURCES OF THE GOODING CITY OF ROCKS
STUDY AREAS, GOODING COUNTY, IDAHO**

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This report was prepared by the Western Field Operations Center, a field report published by the U.S. Geological Survey. The data were collected and interpreted by Bureau of Mines personnel from Western Field Operations Center, East 300 Third Avenue, Spokane, WA 99201. The report has been edited by members of the Branch of Mineral Land Assessment at the Field Center and reviewed at the Division of Mineral Land Assessment, Washington, DC.

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PREFACE

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LIST OF UNIT OF MEASURE ABBREVIATIONS

°	degree
°C	degree Celcius
°F	degree Fahrenheit
day/year	day per year
\$/yd ³	dollar per cubic yard
\$/ton	dollar per ton
ft	foot
in.	inch
in./year	inch per year
mg	milligram
oz/ton	ounce per ton
%	percent
lb/ft ³	pound per cubic foot
mi ²	square mile
ton/day	ton per day
ton/year	ton per year
ohm/cm	ohm per centimeter

SUMMARY

A mineral survey of 19,350 acres of the Gooding City of Rocks Wilderness Study Areas (WSAs) in the north-central Snake River Plain was conducted by the U.S. Bureau of Mines in 1984. No formal mining districts are known in or near the study area.

Forty-two placer claims within and adjacent to the study areas cover the Clover Creek diatomite deposit. Minor production from four pits was reported by the owners. The diatomaceous sediments are underlain by dacitic welded tuff and capped with basalt. Five exposures or blocks totaling 416 million tons of the diatomaceous material comprise the Clover Creek deposit; four of the blocks are in the study areas, but are predominantly covered by basalt. The North Clover block, just west of the areas, is only partially capped, and could be mined by open pit methods on the western flank of the exposure. The minable wedge contains an inferred marginal reserve of 35 million tons of diatomite possibly suitable for filter aid, filler, insulation, and other applications. At a production rate of 150,000 tons/year, total mining and milling costs for high-grade filter aid diatomite would be about \$100/ton. The deposit is classed as marginal because products from this deposit may be inferior to currently marketed diatomite products. The market is well supplied by developed sources.

Several occurrences of platy welded tuff, possibly suitable as decorative stone, are in the areas; however, abundant deposits to the east could be more easily developed. Deposits of sand and gravel are too distant from markets.

Minor gold was detected in a small prospect to the northeast of the study areas. The prospect area may be associated with an ancient hot springs system as suggested by the occurrence of gold, reed molds in opalized volcanic breccia, and scattered silicification.

Existing hot springs and wells north and south of the areas indicate favorable environments for low-temperature geothermal resources; however, no surface manifestations are present within the study areas. No geologic structures favorable for oil and gas are known in the vicinity.

The climate is semiarid. Precipitation averages about 13 in./year; more than half occurs as winter snowfall. Access into the general area is limited to those times when roads are dry or frozen. Flora consists predominantly of sagebrush and various grasses; trees sparsely populate some drainages.

INTRODUCTION

A mineral survey of the major portions of the Gooding City of Rocks Wilderness Study Areas (WSAs) was conducted by the U.S. Bureau of Mines (USBM) and the U.S. Geological Survey (USGS) at the request of the U.S. Bureau of Land Management (BLM). The USBM researched the mining and mineral exploration history and evaluated mines, prospects, and mineralized areas within or adjacent to the study areas. The USGS evaluated the gross mineral potential of the areas by regional geochemical and geophysical surveys and geological mapping. Results of the investigations will be summarized in a joint report used to help determine the suitability of the areas for inclusion into the National Wilderness Preservation System. Although the immediate goal of this and other mineral surveys is to provide data for the President, Congress, government agencies, and the public for land-use decisions, the long-term objective of the USBM surveys is to insure the Nation has an adequate and dependable supply of minerals at a reasonable cost.

Setting

The Gooding City of Rocks study areas cover 19,350 acres in the southeast portion of Mount Bennett Hills, in Gooding County, ID (fig. 1). The two areas are separated by a several-mile-long, north-trending, 4-wheel-drive bulldozer road that connects Hole-in-the-Wall on the south with Bowman Flat on the north. The eastern study area consists of 13,063 acres of the 14,743-acre WSA (ID-54-8a), and the western area (WSA ID-54-8b) consists of 6,287 acres. (Hereafter, the study areas are referred to as WSAs.) The nearest town is Gooding, the county seat, approximately 15 miles by road to the south. Unimproved roads lie near or along three sides of the WSAs. These roads are best reached from State Route 46, five miles to the east.

The highest elevation is 5,615 ft in the northwest portion of the western WSA (fig. 2), and the low point is 4,000 ft on Clover Creek. The study area is dissected by deeply incised, south-flowing streams creating near-vertical canyon walls. The Gooding City of Rocks, an area of extensive erosion in the southeast portion of the eastern WSA, is a popular tourist attraction (Goar, 1978).

The climate is semiarid. Precipitation averages about 10 in./year; more than half occurs as winter snowfall. Access into the general area is limited to those times when roads are dry or frozen. Flora consist predominantly of sagebrush and various grasses; trees sparsely populate some drainages.

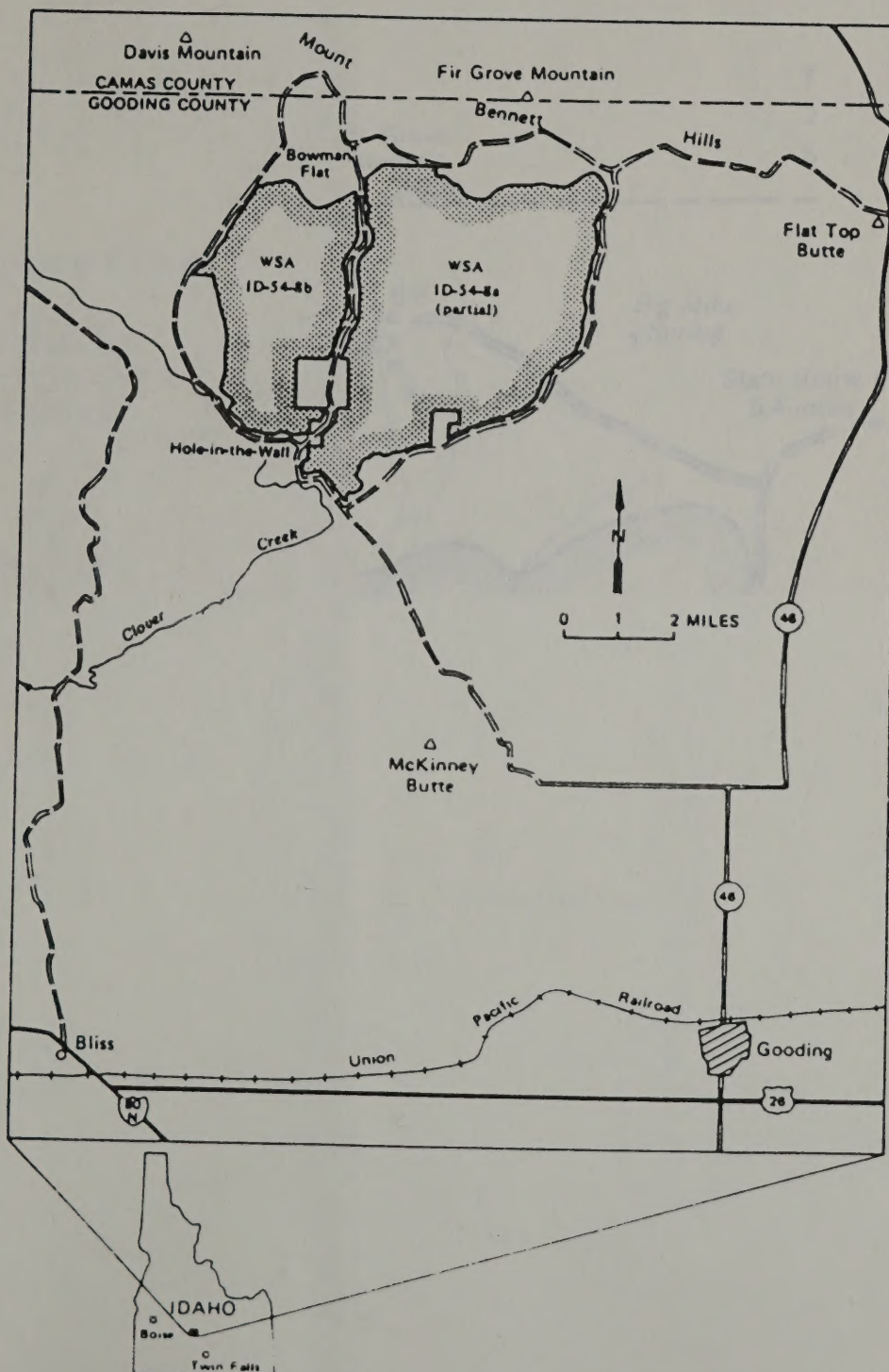


FIGURE 1. - Location map of the Gooding City of Rocks study areas, ID

Previous Studies

Stearns and others (1938) conducted the first major study of the geology and mineral resources of the Snake River Plain. Malde and Powers (1962) described the Upper Cenozoic stratigraphy, and Malde and others (1963) published a reconnaissance geologic map of the west central Snake River Plain. Smith's (1966) thesis describes the geology of eastern Mount Bennett Hills. Rember and Bennett (1979) published a geologic map of the Hailey 2^o quadrangle. Fernette (1983) reported on the geology, energy, and mineral (GEM) resources of the Mt. Bennett Hills area, and Rishel and Dee (1984) studied the Clover Creek diatomite deposit.

Present Study

Work by the USBM, Western Field Operations Center (WFOC), Spokane, WA, entailed pre-field, field, and report preparation phases during the years 1984 and 1985. Pre-field studies included library research and perusal of Gooding County and BLM mining and mineral lease records. Bureau of Mines, State, and other production records were searched and pertinent data compiled. Claim owners were contacted for permission to examine properties and publish the results. On two occasions they accompanied the author to the property.

Frederic L. Kadey, Jr., an acknowledged expert in the evaluation of diatomite deposits, was consulted about the Clover Creek deposit and accompanied the author on a one day visit to the field. Field studies involved searches for all mines, prospects, and claims indicated by pre-field studies to be within the study area. Those found were mapped and sampled. Claims outside, but near the WSAs, also were studied to determine whether mineralized zones might extend into the areas. Both ground and air reconnaissance were used to identify significant geologic structures and zones of alteration related to mineral deposits.

Samples collected by USBM personnel at mines and prospects included 83 of diatomite, 2 of rock, and 1 of alluvium from a dump. In addition, 8 other samples were taken of country rock for chemical analysis, 21 were taken of sand and gravel to examine for placer gold, 7 samples were taken for petrographic analysis, and 5 samples were taken for density determination. Rock samples were of five types : 1) chip - a regular series of rock chips taken in a continuous line across a mineralized zone or other exposure; 2) random chip - an unsystematic series of chips taken from an exposure of apparently homogeneous rock; 3) grab - rock pieces taken unsystematically from a dump, or of float (loose rock lying on the ground); 4) select - pieces of rock chosen, generally, from the apparently best mineralized parts of an exposure or of any particular fraction (e.g. quartz, host rock); and 5) point - a representative volume taken from an exposure of apparently homogeneous material. Diatomite samples were of two types - chip and point. Placer samples were reconnaissance samples from stream-laid sand and gravel. Ten-quart volumes were collected at each site.

Geological Summary

Shaw and others (1953) described the first major study of the geology and mineral resources of the Lake Superior region. Their description of the Lake Superior geology, and their map of the region, are the basis of the present study. Shaw and others (1953) described the geology of the Lake Superior region, and their map of the region is the basis of the present study. Shaw and others (1953) described the geology of the Lake Superior region, and their map of the region is the basis of the present study.

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Most diatomite samples were microscopically examined by USBM staff at WFOC for diatom presence and condition. Suitable samples were submitted to the Manville Service Corporation Research and Development Center (Manville) in Denver, CO, for microscopic examination and determination of crude and ignited color and condition, moisture content, and ignition loss. More detailed characterization studies were conducted by Manville on four of the best diatomite samples. Chemical analysis for 9 major oxides ^{1/} were conducted by the USBM Reno Research Center on 55 of the diatomite samples.

Non-diatomite rock samples, except those collected for petrographic and density testing, were crushed, pulverized, thoroughly mixed, split, and then checked for fluorescence and radioactivity at WFOC. Gold and silver for 13 samples were determined by fire assay followed by inductively coupled plasma analysis (ICP). Other requested metals were determined by ICP. Some rock samples were analyzed for 40 ^{2/} elements by the semi-quantitative spectrographic method to detect unsuspected elements of possible significance. Placer samples, partially concentrated in the field, were further concentrated on a laboratory-sized Wilfley table at WFOC. Resulting heavy mineral fractions were scanned with a binocular microscope to determine heavy mineral content. When gold was detected, larger particles were hand-picked, fine gold was recovered by amalgamation, and then both fractions were weighed. Concentrates were also checked for radioactivity and fluorescence.

ACKNOWLEDGEMENTS

The author was ably assisted in the field by Richard Winters, Steven Robinson, and David Brink. Larry Dee, BLM geologist, Shoshone District, provided aerial photographs, historical information, and logistical support. Edward and Leroy Strout accompanied the author to the diatomite deposit and provided important production data. The author is indebted to Frederic L. Kadey, Jr., who visited the deposit and instructed several USBM employees in the identification and evaluation of diatomite.

-
- ^{1/} Silica (SiO₂), alumina (Al₂O₃), ferric oxide (Fe₂O₃), titania (TiO₂), phosphorus pentoxide (P₂O₅), lime (CaO), magnesia (MgO), sodium oxide (Na₂O), potassium oxide (K₂O).
 - ^{2/} Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, gallium, gold, iron, lanthanum, lead, lithium, magnesium, manganese, molybdenum, nickel, niobium, palladium, phosphorus, potassium, platinum, scandium, silicon, silver, sodium, strontium, tantalum, tellurium, tin, titanium, vanadium, yttrium, zinc, and zirconium.

GEOLOGIC SETTING

The Gooding City of Rocks WSAs are in the southeast portion of an east-trending, uplifted, extensively faulted and eroded core of a southeasterly-tilted horst (Smith, 1966, p. 98). The study area lies in the Columbia-Snake River Plateau geomorphic province (Hunt, 1974, p. 538) and is underlain by the Lower Pliocene Idavada Volcanics and the Middle Pliocene Banbury Basalt. Malde and Powers (1962, p. 1200) define the Idavada Formation as many layers of nonmineralized, silicic, volcanic rocks, predominantly welded ash flows, that include some bedded vitric tuffs and lava flows which unconformably overlie granite and older rhyolite. Smith (1966, p. 10) reports an average collective thickness of about 1,500 ft in ten mappable units. Within the WSAs, the dominant unit is the Gooding City of Rocks Tuff, a flow-structured ignimbrite of dacitic welded tuff with an average thickness of 175 ft (Smith, 1966, p. 55 and 122). It is the erosion of this unit into rounded vertical columns that produces the spectacular City of Rocks. Hyalite opal encrustations and chalcedony fracture-fillings are commonly observed in the Idavada rocks.

The Idavada Volcanics are unconformably overlain, in part, by the Banbury Basalt. The upper section is composed mainly of olivine basalt in columnar lava flows (Malde and Powers, 1962, p. 1204) found to range from 15 to 100 ft in thickness. The middle section of the Banbury is composed of sedimentary deposits; locally these are characterized by thick beds of diatomaceous sediments, discussed in detail in this report. The basal or lower section was not identified in the study area.

Active drainages in the WSAs contain thin deposits of sand and gravel. Several slump blocks in and near the WSAs are associated with zones of weakness in over-steepened slopes of diatomaceous sediments.

MINES, PROSPECTS, AND MINERAL RESOURCES

Mining History

Thomas Conaway and family settled the north end of Ferguson Flat in 1910 and, with George Chaffin and others, located the Bank Bar Nos. 1-3, the first recorded placer claims, on diatomite in sec. 34, T. 3 S., R. 13 E. Numerous subsequent placer claims, including the Crown Point Placer Group in 1918 by Rockhills, Chaffin, and others, the Zeolite Group in 1926 by Chaffin and others, the Snowdrift Group in the mid-1930's by Becker, Chaffin, and others, and many real estate exchanges were made by various parties through the 1970's.

The Strout family, first Leonard Strout and later Edward Strout, has been involved in the ownership of the claims since the 1930's. The numerous placers were consolidated into one property by Edward Strout in 1974. He reported (personal communication, 1984) that the first production of diatomite from the property occurred about 1930. It was shipped to Gooding by horse-drawn wagon and then in two rail cars to a sugar factory in Utah, possibly for use as a filter aid. In the mid-1930's, 50 to 150 ton/year were sold to the Sterling Lumber Co. of Twin Falls for use as insulation. An attempt to use the diatomite as an additive to hot asphalt for roof application in the 1940's did not succeed. During the 1950's and 1960's, claimants sold modest amounts of crude diatomite in southern Idaho for use as an athletic field marker. According to Mr. Strout, the diatomite was displaced from the 100 ton/year market by by-product calcined gypsum. Diatomite production was from four open pits along the southwestern boundary of the WSAs, most from a site identified as the "Chalk" Mine on the Davis Mountain 15 minute topographic quadrangle. Mr. Strout also noted that Manville examined the deposit about 1960; however, no data are available. Currently, assessment work is done on the claims.

R. K. Johnson located the R.K. and M. lode claim and the Queen Marie and Blue Flower placer claims five miles west of Flat Top Butte in July, 1932. The claims were probably situated near but outside of the eastern boundary road of WSA-8a. Ted Neeley located and explored the Red Dot Claim for mercury in sec. 3, T. 3 S., R. 14 E. about 1968 (Larry Dee, personal communication, 1984).

Diatomite

Definition and Classification

Diatomite is a light-colored, siliceous, sedimentary rock which consists of the microscopic remains of diatoms -- one-celled aquatic plants related to algae. Deposits are formed by the induration (compaction) of diatomaceous oozes. The rock is commonly soft, friable, and lightweight. Diatomite (or diatomaceous earth) is a term generally reserved for deposits of actual or potential commercial value. Useful characteristics, primarily due to the siliceous diatom skeletons, are a high surface area, high absorptive capacity, and relative chemical stability (Bates and Jackson, 1980, p. 173; Kadey, 1983, p. 677).

Most of the known diatomite deposits in the world are of freshwater origin; however, the largest deposits are marine. Other classes include deposits of modern lake, marsh, bog, or brackish origins. Freshwater deposits occur in many localities in the western United States; however, the largest producer is the marine deposit at Lompoc, CA. The assemblage of diatom forms (species or genera) is used to determine the deposit origin, and is unique to each deposit or geographic area (Kadey, 1983, p. 683). The type, variety, and condition of the diatom skeletons determine the suitability of a deposit for particular applications.

Production

From 1973 through 1984, total domestic production of diatomite ranged from a low of 573,000 tons in 1975 to a high of 717,000 tons in 1979. Four states - California, Nevada, Washington, and Oregon (in order of production) - account for all output. More than half is from the marine deposits in southern California. Since 1978, 23% to 25% of domestically produced diatomite has been exported, while imports, mostly from Mexico, have been negligible. U.S. production from 1978 through 1981 ranged from 40% to 43% of world output, and in 1982 and 1983 it was 37% of world output (Meisinger, 1982, p. 309-310; 1984, p. 321-322; Kadey, 1983, p. 697).

Applications

Uses for diatomite are extremely varied. The widest use for processed diatomite is as a filter aid for the separation of suspended solids from fluids. Filtration applications include beer and wine, sugar, dry cleaning, swimming pool waters, fruit juices, and organic and inorganic chemicals (Robertson, 1960, p. 15; Benton, 1983, p. 1). Of 1983 domestic production, 66% was sold as a filter aid and 21% was sold as a filler or extender, the second largest use (Meisinger, 1984, p. 322). Fillers may be used as bulk mineral fillers or as functional fillers. Benton (1983, p. 1) notes:

"Paint, plastics and paper are some of the major markets. Diatomite is used in paint as a low cost pigment extender and as a flattening agent. In plastics, it is used as an anti-blocking agent for film. In paper, diatomite is used as a lightweight bulking agent, a drainage aid and as a low cost opacity builder."

Manville Corp. at Lompoc, CA, produces 12 different diatomite filter-aid products, each designed to meet a specific filtration requirement. In addition, 11 natural, 6 calcined, and 17 flux-calcined diatomite filler products are sold. Diatomite applications requiring minimal processing are varied, but limited by amount of demand. Three percent of the 1983 domestic production went for use as insulation, while the remaining 10% went for such diverse uses as absorbants, silica additives to cement, abrasives (polishing compounds), catalysts, lightweight aggregates for soil conditioners, and as chemical carriers. Although there are a great number of product types and a variety of applications, Kadey (1983, p. 697) notes that the probability of economic success for a potential deposit is seriously reduced if it cannot be processed into one or more filter-aid products.

Diatomite Marketing

Although the author contacted representatives of the major U.S. diatomite producers, the industry is of such competitive nature that little useful cost information was obtainable. Specific market areas and volumes, and product prices and specifications are commonly held in confidence. Because every diatomite deposit is unique, a full marketing study was beyond the scope of this investigation.

Published literature and unpublished USBM statistical files show a significant price distinction between marine- and non-marine-derived (mostly fresh water) diatomite products. The most recent year of published prices, by end use (Meisinger, 1984, p. 322), shows average values in 1983 of \$200/ton for filter aids, \$177/ton for fillers, \$119/ton for insulation, and an average \$116/ton for other uses. These prices reflect a composite of marine and non-marine types. Table 1 shows a comparison of production and average value by end use for composite and non-marine production for the years 1978 through 1984. Based on the composite to non-marine price ratios, it is estimated that current (1985) values average about \$170/ton for filter aids, over \$95/ton for filler aids, \$150/ton for insulation, and \$100/ton for other uses (prices are FOB 3/ plant site). According to a market survey conducted by Larry Dee, BLM staff geologist, Shoshone, ID (personal communication, 1984), two food processing plants in south central Idaho purchase various filtration grades of diatomite from a Nevada company for an average price of \$200/ton including freight.

Clover Creek Deposit

Geology

Thick deposits of diatomaceous sediments deposited in an ancient freshwater lake are along the western and southwestern boundaries of the WSAs east of Clover and Square Creeks, predominantly within WSA 54-8b. Other facies (sedimentary units) associated or interbedded with these sediments are lenses and beds of sand, silt, clay, ash, and chert as well as at least one lenticular-shaped sand and pebble-gravel river channel deposit. Figure 3 shows the distribution of the sedimentary deposits, and identifies the five main exposures or blocks of observed and inferred diatomaceous material comprising the Clover Creek deposit. In total areal extent, these blocks cover 4.4 mi², of which about 2 mi² are covered by 15- to 20-ft-thick partial cappings of Banbury Basalt. The diatomaceous deposit is over 440 ft thick in the Ferguson block. The configuration of the Catchall and Ferguson blocks - thin near their eastern edges - and the presence of beach sands and near-shore sediments in the "Chalk" Mine block, suggest that the eastern exposure of the deposit may have formed part of the original lake shoreline.

3/ FOB: free on board; indicates material that is loaded and ready for delivery.

TABLE 1.--Production statistics - U.S. diatomite production by end use - 1978-1984

End use	Average annual production 1/ 1978-1984 (tons)	Average unit value 1978-1984 (\$/ton)	Average annual non-marine 2/ production 1/ 1978-1984 (tons)	Average non-marine unit value 1978-1984 (\$/ton)
Filter aid	429,000	164	170,000	137
Filler aid	141,000	144	54,000	79
Insulation	16,000	107	13,000	93
Other 3/	71,000	103	50,000	91
Total 4/	658,000		Total 4/ 289,000	
		Weighted average 156		Weighted average 126

1/ Data from U.S. Bureau of Mines statistical files.

2/ Excludes California production which is predominantly of marine origin.

3/ May include absorbants, silica additives to cement, abrasives, catalysts, lightweight aggregate, soil conditioner, chemical carrier.

4/ Data may not add to totals shown because of independent rounding.

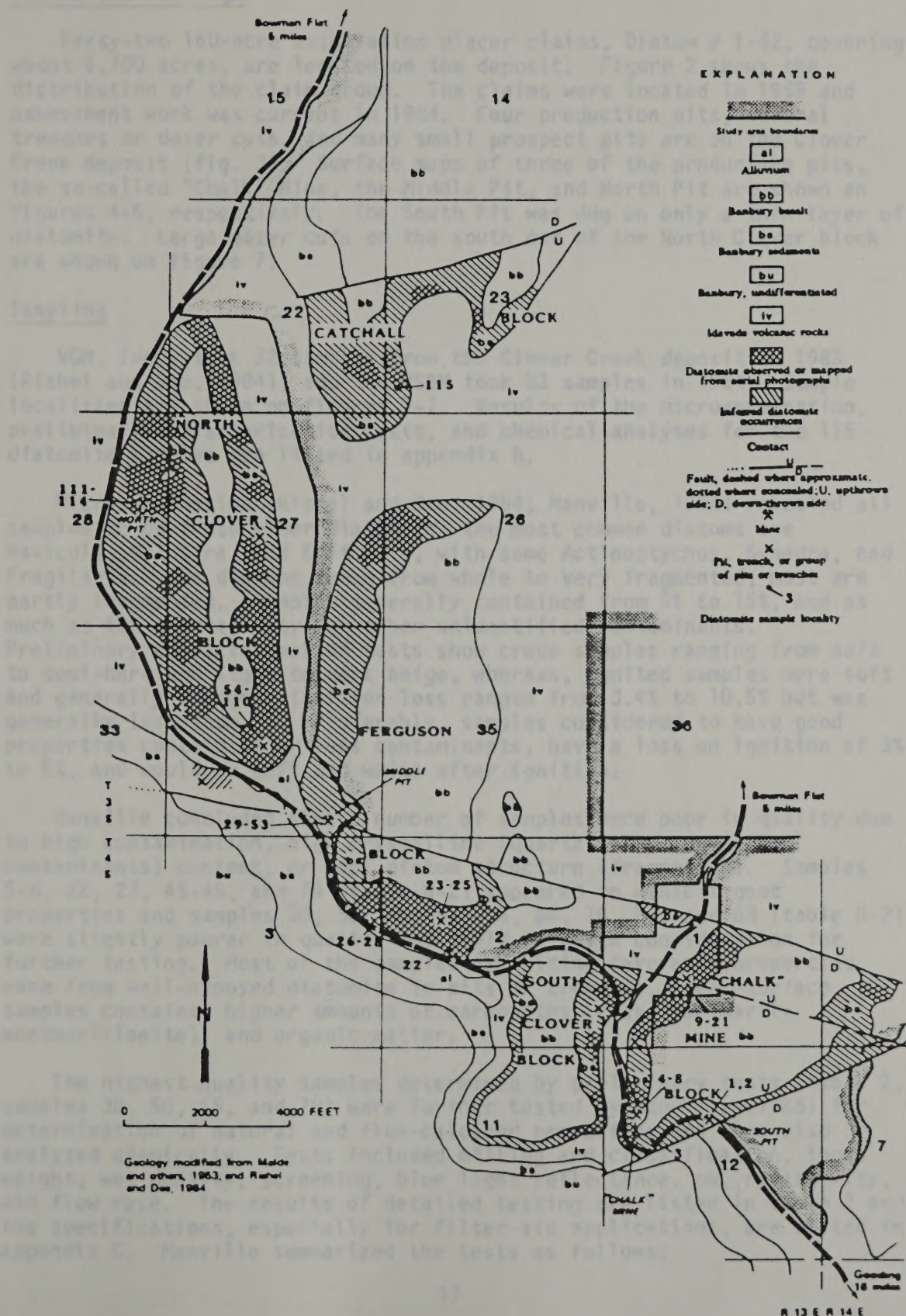


FIGURE 3. — Map of the Clover Creek diatomite deposit along the west boundary of the Gooding City of Rocks study areas

Claims and Workings

Forty-two 160-acre association placer claims, Diatom # 1-42, covering about 6,700 acres, are located on the deposit. Figure 2 shows the distribution of the claim group. The claims were located in 1959 and assessment work was current in 1984. Four production pits, several trenches or dozer cuts, and many small prospect pits are on the Clover Creek deposit (fig. 3). Surface maps of three of the production pits, the so-called "Chalk" Mine, the Middle Pit, and North Pit are shown on figures 4-6, respectively. The South Pit was dug on only a thin layer of diatomite. Large dozer cuts on the south end of the North Clover block are shown on figure 7.

Sampling

WGM, Inc., took 32 samples from the Clover Creek deposit in 1983 (Rishel and Dee, 1984), and the USBM took 83 samples in 1984. Sample localities are shown on figures 3-7. Results of the microexamination, preliminary characterization tests, and chemical analyses for the 115 diatomite samples are listed in appendix B.

Microexamination (Rishel and Dee, 1984; Manville, 1984) revealed all samples to be fresh water diatomite; the most common diatoms are *Navicula*, *Melosira*, and *Epithemia*, with some *Actinopterychus*, *Synedra*, and *Fragilaria*. The diatoms range from whole to very fragmented; most are partly fragmented. Samples generally contained from 5% to 15%, and as much as 40% quartz, clay, or other unidentified contaminants. Preliminary characterization tests show crude samples ranging from soft to semi-hard and light to dark beige, whereas, ignited samples were soft and generally orange. Ignition loss ranged from 3.4% to 10.5% but was generally less than 5%. Preferably, samples considered to have good properties contain 5% or less contaminants, have a loss on ignition of 3% to 5%, and would be soft and white after ignition.

Manville concluded that a number of samples were poor in quality due to high contamination, high crystalline (quartz, clay, and other contaminants) content, or poor diatom structure (fragmented). Samples 5-8, 22, 23, 45-49, and 79 (table B-2) appeared to exhibit good properties and samples 30, 50, 55, 57, 58, 64, 76, 82, and 88 (table B-2) were slightly poorer in quality but could be given consideration for further testing. Most of the samples exhibiting favorable properties came from well-exposed diatomite in pits or trenches. Near-surface samples contained higher amounts of carbonates, clays (primarily montmorillonite), and organic matter.

The highest quality samples determined by preliminary tests (table 2, samples 30, 50, 55, and 79) were further tested by Manville (1985) for determination of natural and flux-calcined properties and were also analyzed chemically. Tests included milling and classification, loose weight, wet density, screening, blue light reflectance, pH, resistivity, and flow rate. The results of detailed testing are listed in table 2 and the specifications, especially for filter-aid applications, are listed in appendix C. Manville summarized the tests as follows:

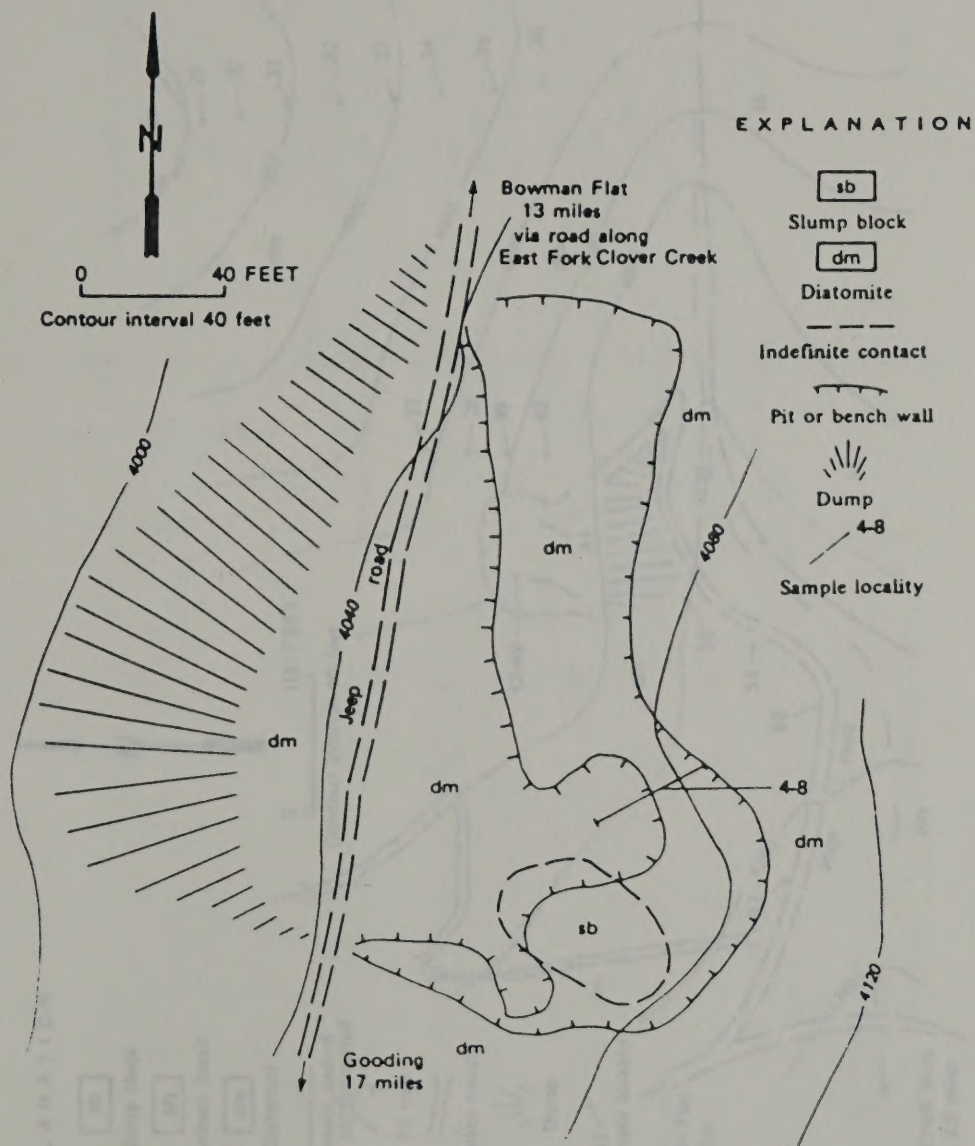


FIGURE 4. — Map of "Chalk" Mine

EXPLANATION

- sb Slump block
- bb Banbury basalt
- dm Diatomite

Contact, dashed where approximated

Pit wall

Dozer trench

Dump

41 Sample locality

Bowman Flat
10 miles

"Chalk" Mine
2.5 miles

0 100 FEET
Contour interval 40 feet

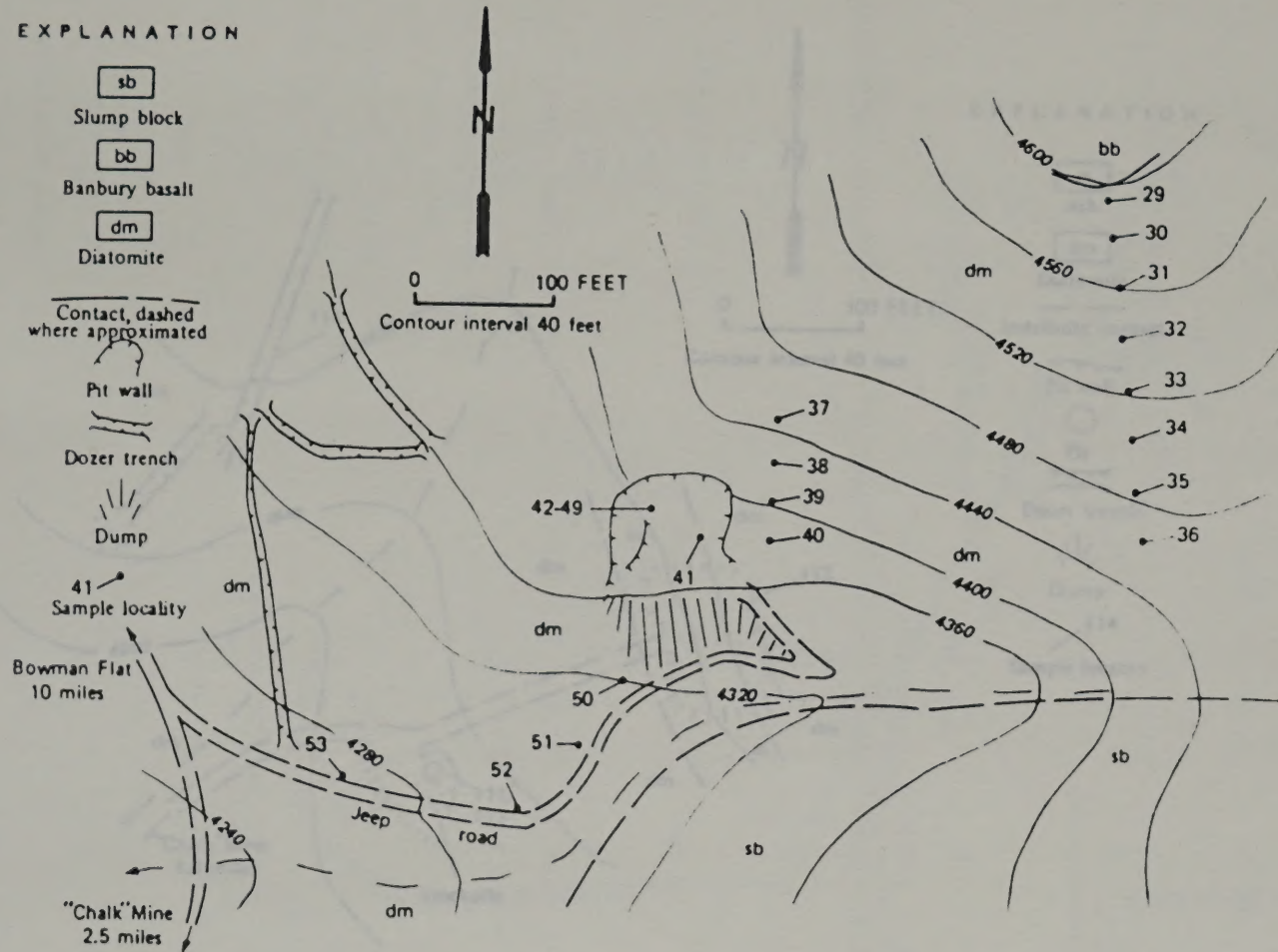


FIGURE 5. — Map of Middle Pit

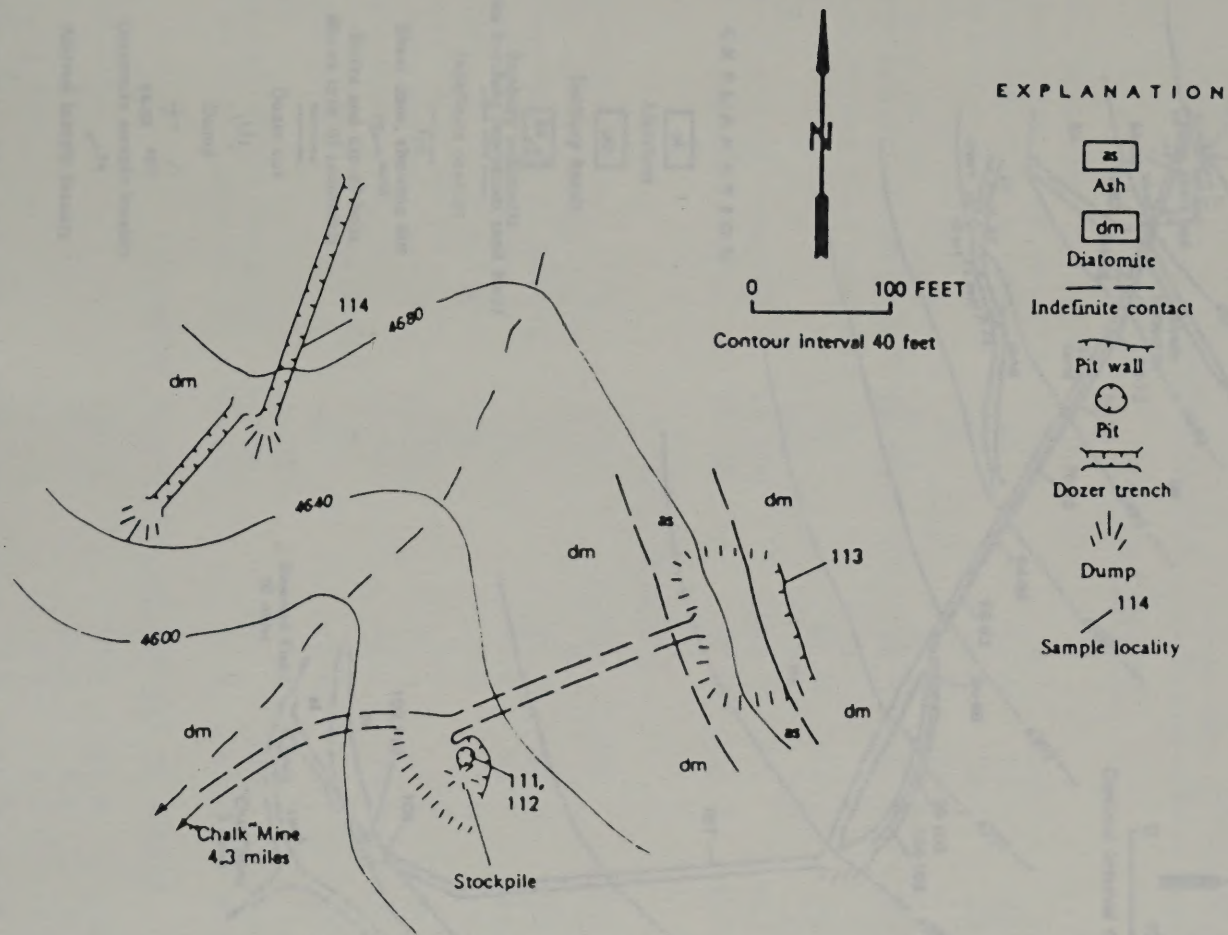


FIGURE 6. — Map of North Pit

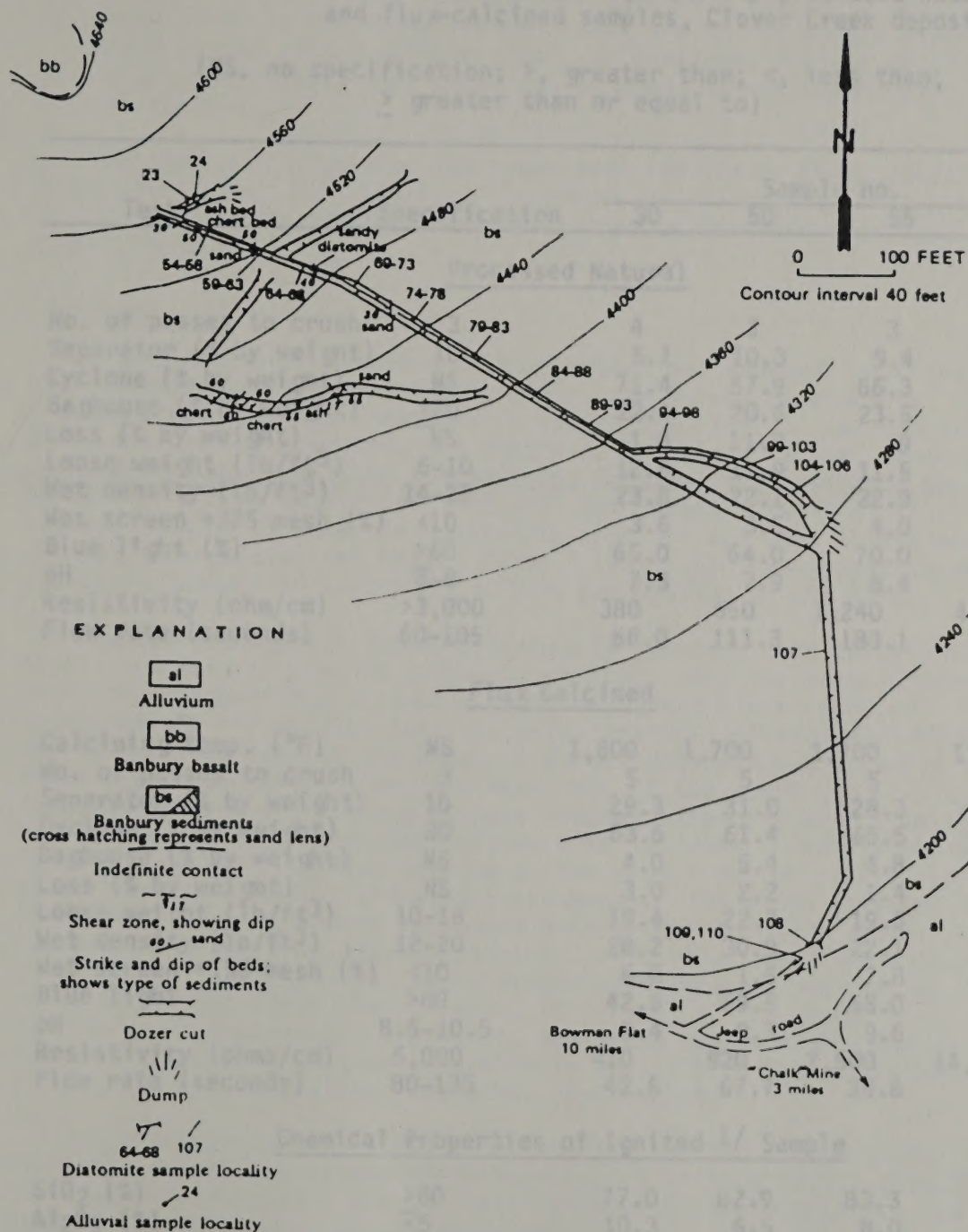


FIGURE 7. — Map showing sample localities of dozer cuts in sec. 34 T. 3 S., R. 13 E., B.M.

1/ Ignited; heated to 1,000°C to volatilize water and organic matter.

TABLE 2.--Milling, classification, physical, and chemical properties of four high-quality processed natural and flux-calcined samples, Clover Creek deposit

(NS, no specification; >, greater than; <, less than;
≥ greater than or equal to)

Test	Specification	Sample no.			
		30	50	55	79
<u>Processed Natural</u>					
No. of passes to crush	3	4	3	3	3
Separator (% by weight)	10	5.1	10.3	9.4	11.3
Cyclone (% by weight)	NS	71.4	57.9	66.3	58.9
Baghouse (% by weight)	<20	22.4	20.6	23.5	24.0
Loss (% by weight)	NS	1.0	11.3	.9	5.9
Loose weight (lb/ft ³)	6-10	12.6	11.9	11.5	11.0
Wet density (lb/ft ³)	14-22	23.8	22.1	22.9	22.9
Wet screen +325 mesh (%)	<10	3.6	3.5	4.0	4.2
Blue light (%)	>60	65.0	64.0	70.0	70.5
pH	6-8	7.3	7.9	8.4	8.3
Resistivity (ohm/cm)	>3,000	380	650	1,240	4,100
Flow rate (seconds)	60-105	66.0	111.3	183.1	581.5
<u>Flux Calcined</u>					
Calcining temp. (°F)	NS	1,600	1,700	1,700	1,700
No. of passes to crush	3	5	5	5	5
Separator (% by weight)	10	29.3	31.0	28.3	22.6
Cyclone (% by weight)	80	63.6	61.4	65.5	65.8
Baghouse (% by weight)	NS	4.0	5.4	4.8	7.9
Loss (% by weight)	NS	3.0	2.2	1.4	3.7
Loose weight (lb/ft ³)	10-18	19.4	22.3	19.6	21.3
Wet density (lb/ft ³)	12-20	28.2	30.9	22.1	22.1
Wet screen +150 mesh (%)	<10	6.0	1.5	7.8	10.2
Blue light	>80	42.5	59.5	58.0	48.0
pH	8.5-10.5	9.4	9.3	9.6	9.4
Resistivity (ohms/cm)	5,000	410	920	2,500	14,400
Flow rate (seconds)	80-135	42.8	67.7	38.8	71.4
<u>Chemical Properties of Ignited ^{1/} Sample</u>					
SiO ₂ (%)	>80	77.0	82.9	83.3	84.9
Al ₂ O ₃ (%)	<5	10.3	6.5	8.0	7.3
Fe ₂ O ₃ (%)	<2	3.9	2.3	2.8	2.4
CaO (%)	<1	1.5	2.6	1.2	1.3
Na ₂ O (%)	NS	1.1	.5	.6	.2

^{1/} Ignited: heated to 1,000°C to volatilize water and organic matter.

"It is concluded, based on these four samples, that filter aid products could be made from similar materials but their quality would be inferior to diatomite products that are in the market place today, based on the stated deficiencies. In addition, because of their poor color (not white), they could not be used in most major filler applications."

One sample of diatomite was taken from the Clover Creek deposit by Treco Industries, Inc. (1974). The sample was classed as "very high quality" diatomite suitable for application to filtration products and animal feed.

Resources

From cross-sections based on topographic and geologic maps (Malde and others, 1963, and Rishel and Dee, 1984), the volume of probable diatomaceous sediments contained in each block (fig. 3) was calculated using the mean-area method. To determine a tonnage factor, three samples of diatomite were analyzed for apparent density; they averaged 50 lb/ft³. The area studied is estimated to contain a total of 416 million tons of diatomaceous sediments; 232 million tons within and 184 million tons outside the WSAs. Table 3 lists the average thickness and estimated tonnage in each block within and outside of the WSAs.

Because the overall deposit pinches to the east, and certain of the blocks are largely covered with a basalt cap, only the North Clover block contains an identified diatomite resource. That block contains approximately 147 million tons, is only partially covered with basalt, and is entirely outside the WSAs. A large, wedge-shaped exposure of diatomaceous sediments along the west side of the North Clover block could be surface mined along stepped benches without undermining the basalt cap, and with a minimum exposure to the WSAs. There would be a hypothetical 30° pit slope dipping to the west from the basalt cap due to the instability of diatomaceous sediments. The wedge contains about 50 million tons of Banbury sediments between the overlying Banbury Basalt cap and the underlying Idavada Volcanics (fig. 8). Based on a sample suite (fig. 7, nos. 54-110) and a mapped stratigraphic section at the south end of the North Clover block, 70 percent of the wedge is considered diatomaceous. Therefore, the wedge contains an inferred resource of 35 million tons of diatomite possibly suitable for certain filter, filler, insulation, and other applications.

Treco Industries, Inc. (1974) estimated that the Clover Creek diatomite deposit contained approximately 1.5 billion tons. This figure is considered excessive but may have included possible diatomite in Banbury sediments west of the study area.

TABLE 3.--Cumulative tonnage of probable diatomaceous sediments within and adjacent to the Gooding City of Rocks study areas

(NAP, not applicable)

Block	Average thickness (ft)	Tonnage within WSAs (million tons)	Tonnage outside WSAs (million tons)	Total (million tons)
Catchall	195	34	None	34
"Chalk" Mine	160	61	8	69
Ferguson	365	137	3	140
North Clover	310	None	147	147
South Clover	120	None	26	26
Totals	NAP	232	184	416

FIGURE 8. -- Surface map and section of hypothetical mine area, North Clover block, outside the west boundary of the Gooding City of Rocks study areas

TABLE 3--Comparative summary of average expenditures within and adjacent to the Spotted Owl's range

(in \$, not adjusted)

Area	Average expenditure (%)	Number within range (million acres)	Number outside range (million acres)	Total (million acres)
California	188	36	600	636
"Oregon" Range	180	61	5	66
Washington	168	137	3	140
North Oregon	110	none	147	147
South Oregon	110	none	28	28
Total	146	234	883	1,117

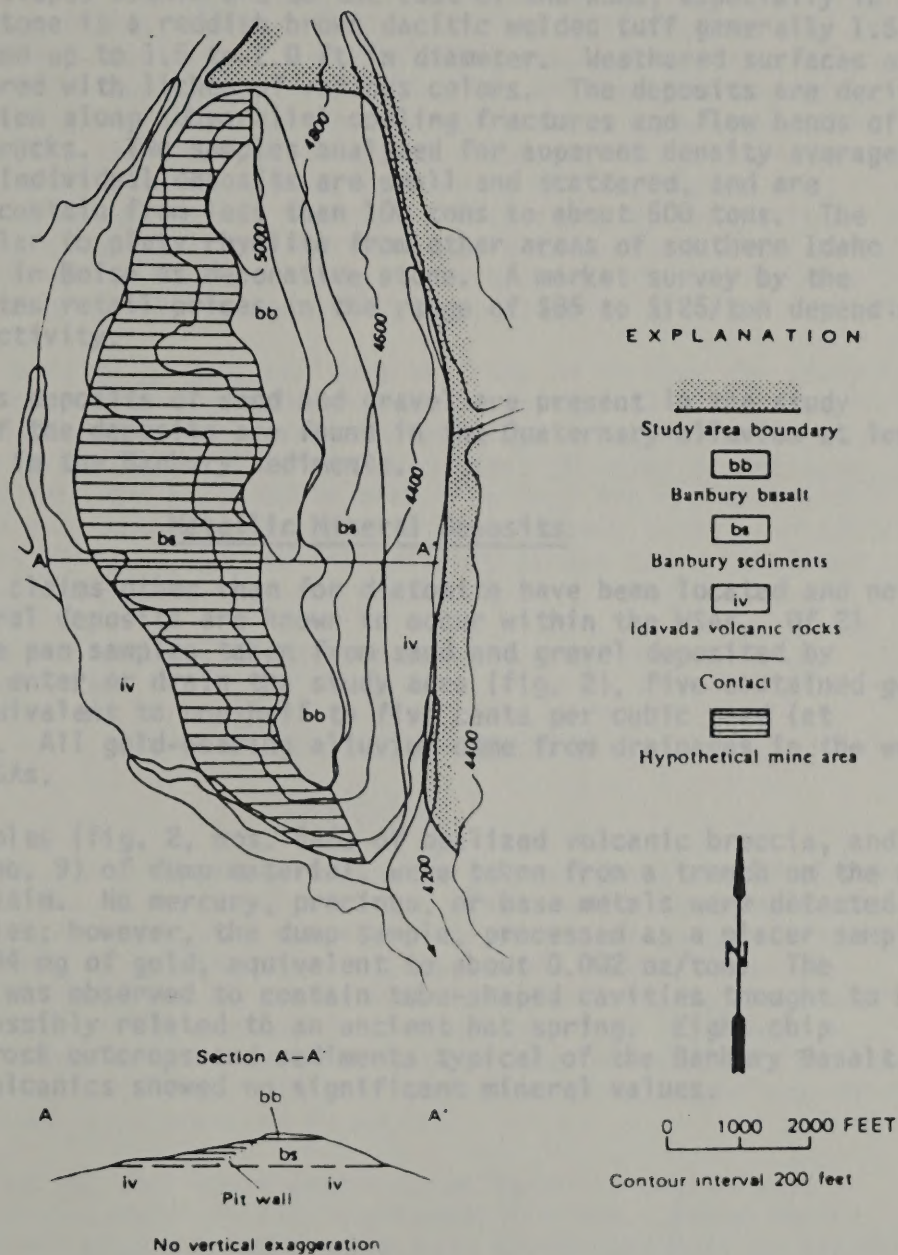
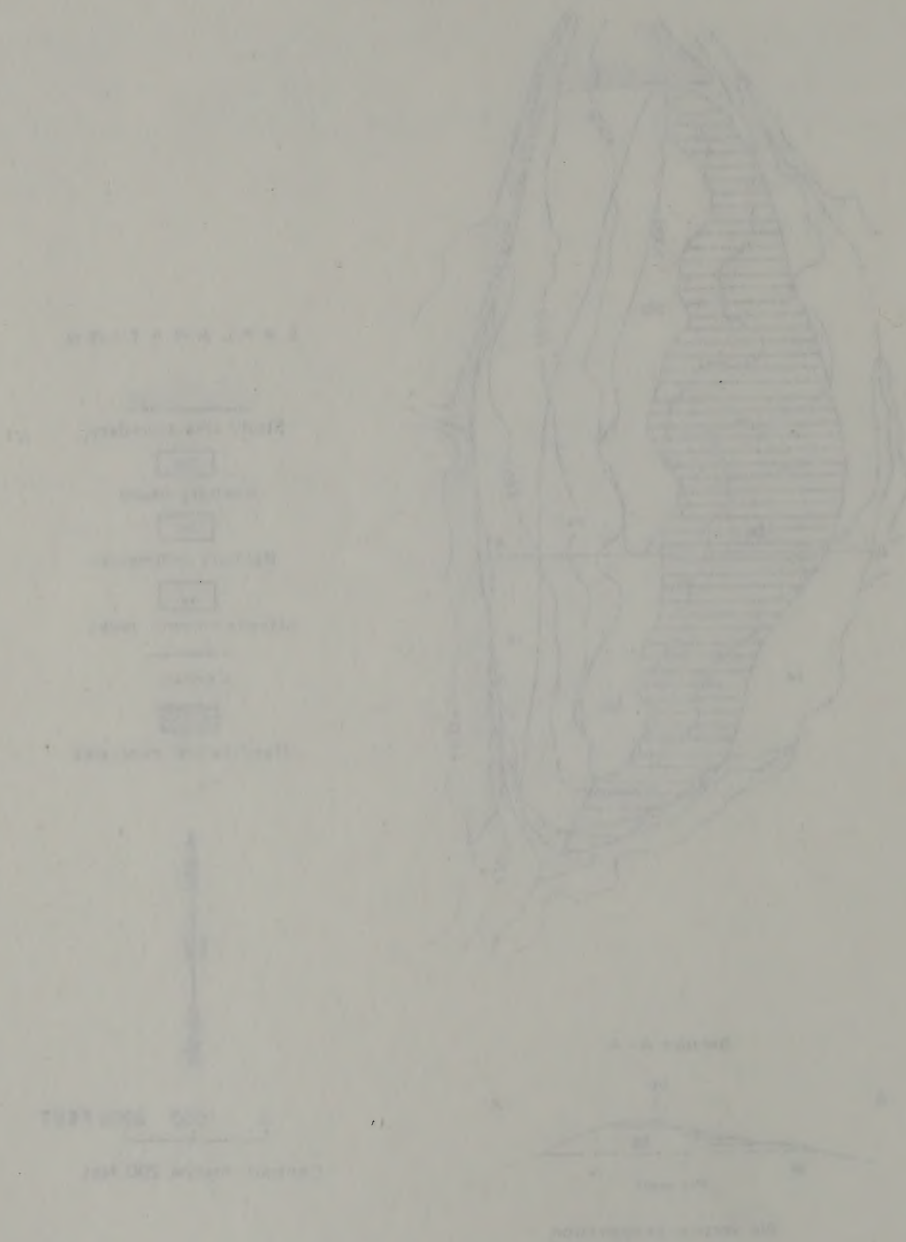


FIGURE 8. — Surface map and section of hypothetical mine area, North Clover block, outside the west boundary of the Gooding City of Rocks study areas

FIGURE 2. Section near and between of symmetrical mountain peaks. Note: The section is outside the water boundary of the sounding line of the water study zone.



Rock Products

Small deposits of platy rock of Idavada Volcanics are on the surface and on talus slopes within and to the east of the WSAs, especially in WSA 54-8a. The stone is a reddish brown dacitic welded tuff generally 1.5 to 3 in. thick and up to 1.5 to 2.0 ft in diameter. Weathered surfaces are commonly covered with lichen of various colors. The deposits are derived from exfoliation along subparallel cooling fractures and flow bands of the volcanic rocks. Two samples analyzed for apparent density averaged 145 lb/ft³. Individual deposits are small and scattered, and are estimated to contain from less than 100 tons to about 500 tons. The stone is similar to platy rhyolite from other areas of southern Idaho which is sold in Boise as decorative stone. A market survey by the author indicates retail prices in the range of \$85 to \$125/ton depending on building activity.

Voluminous deposits of sand and gravel are present in the study area. Most of the deposits are found in the Quaternary alluvium at lower elevations or in the Banbury sediments.

Metallic Mineral Deposits

No mining claims other than for diatomite have been located and no metallic mineral deposits are known to occur within the WSAs. Of 21 reconnaissance pan samples taken from sand and gravel deposited by streams which enter or drain the study area (fig. 2), five contained gold in amounts equivalent to one-half to five cents per cubic yard (at \$300/oz gold). All gold-bearing alluvium came from drainages in the west half of the WSAs.

Three samples (fig. 2, nos. 6-8) of opalized volcanic breccia, and a grab sample (no. 9) of dump material, were taken from a trench on the Red Dot Mercury Claim. No mercury, precious, or base metals were detected in the rock samples; however, the dump sample, processed as a placer sample, contained 0.184 mg of gold, equivalent to about 0.002 oz/ton. The opalized rock was observed to contain tube-shaped cavities thought to be reed molds, possibly related to an ancient hot spring. Eight chip samples from rock outcrops and sediments typical of the Banbury Basalt and Idavada Volcanics showed no significant mineral values.

Data are lacking that would enable an estimate of capital and operating costs of a major diatomite processing plant. Costs for a hypothetical plant adjacent to the WSAs were determined here by analogy or proportion. Eagle Picher Industries, Inc. is planning a \$12 million processing plant to be built in east-central Oregon to replace some or all of their Nevada operations (The Daily Argus Observer, January 18, 1984; Matheur Enterprise, February 7, 1984). The plant is designed to employ 30 to 35 workers and to operate for 40 years. Cost data for that plant, and from Benton (1983), were used to supplement costs determined by the USBM Cost Estimating System (STRAM Engineers, Inc., 1977).

Energy Resources

The WSAs lie near the center of a cluster of geothermal reservoirs possibly related to faulting along the perimeter of the Snake River Plain downwarp (Mabey, 1983). Waring (1965, p. 13 and 30), Breckenridge and others (1980), U.S. Geological Survey (1982), and Leah Street (Idaho Department of Water Resources, Twin Falls, ID, written communication, 1985) identified several hot springs and wells and a warm-water lake about 4 to 6 miles southwest of the study area. Surface temperatures range from a low of 27°C in Hot Sulfur Lake to 43° to 65°C in the hot springs. Three geothermal reservoirs identified by Mabey (1983, p. 3 and 11) at Wardrop and Barron's Hot Springs in Camas Prairie to the north and Magic Reservoir to the east contain estimated geothermal reservoir temperatures of 97°C, 103°C, and 147°C, respectively.

There has been no geothermal lease activity in or near the study area as of 1984, and no surficial manifestations of geothermal energy are known to occur within the WSAs. Exploration drilling for geothermal resources was conducted in the late-1970's on lands about 20 miles to the east, in the Magic Reservoir and Black Butte area. Springs are abundant along both the north and south facing slopes of the Bennett Hills, immediately to the north of the WSAs, and an intermittent stream named Hot Creek drains into the study area from the north.

No oil and gas, coal, or uranium prospecting activity has been recorded in the WSAs.

APPRAISAL OF MINERAL RESOURCES

Diatomite

Although the Clover Creek diatomite is only marginally suitable for filter applications, a hypothetical major mining and processing operation was designed to produce a wide variety of products, including filter aids and fillers. Such an operation would account for one-half the U.S. output of 300,000 ton/year of non-marine diatomite products. Production would be at a rate of 500 ton/day for 300 day/year. A 2:1 crude-(inplace) to-product weight ratio was assumed, due primarily to milling losses (Kadey, 1983, p. 692). At this production rate, about one-third of the deposit would be mined in 40 years.

Data are lacking that would enable an estimate of capital and operating costs of a major diatomite processing plant. Costs for a hypothetical plant adjacent to the WSAs were determined here by analogy or proportion. Eagle Picher Industries, Inc. is planning a \$13 million processing plant to be built in east-central Oregon to replace some or all of their Nevada operations (The Daily Argus Observer, January 18, 1984; Malheur Enterprise, February 7, 1984). The plant is designed to employ 30 to 35 workers and to operate for 40 years. Cost data for that plant, and from Benton (1983), were used to supplement costs determined by the USBM Cost Estimating System (STRAAM Engineers, Inc., 1977).

Energy Resources

The WSA is near the center of a cluster of potential resources possibly related to existing along the perimeter of the Great River Plate (Haley, 1981). During 1982, p. 13 and 30). Evaluation and others (1980), U.S. Geological Survey (1982), and 1982. The Department of Water Resources, Tulsa, 1982. 10. The investigation (1982) identified several hot springs and wells and a geothermal field about 4 to 6 miles southeast of the study area. Studies conducted range from a low of 230°C in the Hot Sulphur Lake to 65°C in the Hot Springs. These geothermal resources identified by Haley (1982, p. 2 and 11) at Wadsworth and Barton's Hot Springs in Lamar Park to the north and Hot Springs to the east could be considered potential resources. Temperatures of 230°C, 180°C, and 140°C, respectively.

There are also no potential fossil activity in or near the study area as of 1982, and no potential manifestation of potential energy resources in or near the WSA. Evaluation during the geothermal resources was conducted in the late 1980's on lands about 20 miles to the east. The study identified several hot springs and wells and a geothermal field about 4 to 6 miles southeast of the study area. Studies conducted range from a low of 230°C in the Hot Sulphur Lake to 65°C in the Hot Springs. These geothermal resources identified by Haley (1982, p. 2 and 11) at Wadsworth and Barton's Hot Springs in Lamar Park to the north and Hot Springs to the east could be considered potential resources. Temperatures of 230°C, 180°C, and 140°C, respectively.

As of 1982, no coal, oil, or natural gas activity has been reported in the WSA.

APPENDIX OF MINERAL RESOURCES

Introduction

Although the Great River Plate is only marginally suitable for other applications, a hypothetical major mining and processing operation was designed to produce a wide variety of products, including other minerals. Such an operation would account for one-half the U.S. output of 300,000 tons/year of non-ferrous aluminum production. Production would be at a rate of 300 tons/year for 100 days/year. A 2:1 energy (input) to product weight ratio was assumed, but actually no mining (Haley, 1982, p. 485). At this production rate, about one-third of the deposit would be mined in 40 years.

Data are lacking that would enable an estimate of capital and operating costs of a major aluminum processing plant. Costs for a hypothetical plant adjacent to the WSA were determined here by analogy to operations. Eagle River Industries, Inc. is planning a \$15 million processing plant to be built in east-central Oregon to replace one of its Utah Nevada operations (The Daily Press Observer, January 18, 1982; The Daily Press Observer, February 7, 1982). The plant is designed to employ 30 to 35 workers and to operate for 40 years. Cost data for that plant, and from Barton (1982), were used to supplement costs determined by the USGS Cost Estimating System (STRAUS Engineering, Inc., 1977).

A processing plant would best be located at Bliss or Gooding, ID, where there are rail facilities and an interstate highway. Overall costs of the hypothetical operation were estimated as follows:

	<u>Production Cost (\$/ton)</u>
Exploration and haulage roads	1.12
Mine capital (including power)	.48
Plant capital	2.17
Mine operation	8.58
Truck 17 mi to plant at Bliss, ID	9.48
Direct processing	51.48
Packaging and shipment preparation	<u>25.74</u>
Total	99.05

Typical rail freight costs for transporting materials like diatomite 150 to 600 miles are about \$9.50 to \$38/ton.

If the diatomite were suitable for filtration and filler applications, and if current markets were not dominated by presently producing companies, a variety of diatomite products might be produced at a profit from the Clover Creek deposit. Several products other than filter aids could be produced at a substantially lower processing cost (both capital and operating), estimated to be about \$10 to \$20/ton, but the delicate drying and classifying operations would still be energy intensive (Benton, 1983). Because the current market for diatomite products is filled by the existing deposits, and major increases in demand are not expected in the near future, the 35 million ton North Clover block is classified as an inferred marginal reserve. A significant technological improvement in upgrading diatomite, or a substantial increase in demand, could change the classification to that of reserve. Also, further exploration or drilling might lead to discovery of higher grade portions of the deposit better suited for filtration applications.

Other Mineral Products

Abundant deposits of rhyolitic decorative stone occur on accessible lands to the east of the WSAs. Therefore, deposits of stone, possibly suitable as a decorative veneer, which occur within the WSAs are classified as occurrences. Due to the high bulk, low unit value of sand and gravel and the high transportation costs involved in shipping, there is little chance for development of the WSAs deposits, other than for minor local uses.

REFERENCES

Although gold was found in alluvial samples, no resources were identified within or near the WSAs. Several characteristics of the area may be indicative of epithermal, hot-spring-type gold deposits. High-angle faults associated with the Bennett Hills uplift, felsic volcanic rocks, and the small, lacustrine basin in the study area are all characteristic of the geologic environment associated with this deposit type (Silberman, 1982, p. 133). The reed molds and opalized volcanic breccia, as well as the presence of abundant hyalite opal encrustations and chalcedony fracture-fillings, are direct evidence of surface or near surface hot-spring sinter deposits. Epithermal hot-spring gold deposits are commonly disseminated, are of low grade and large tonnage, and are generally of mid-Tertiary or younger age (Silberman, 1982). Surficial manifestations may cover from less than 1 mi² to nearly 10 mi².

Lands immediately to the north and south of the WSAs are classified by the U.S. Geological Survey (1982) as prospectively valuable for geothermal resources. Although the nearest known geothermal resource area (KGRA) is at Mountain Home about 25 miles to the west, the presence of hot springs to the north, south, and east is indicative of an environment favorable for geothermal resources within the WSAs.

Most of southern Idaho is identified by the U.S. Geological Survey (1980) as prospectively valuable for oil and gas resources; however, no structures are known in or near the study area.

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RESERVE.--Material occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

IDENTIFIED RESOURCES.--Resources whose location, grade, quality, and quantity are shown or estimated from specific geologic evidence. Identified resources include economic, marginally economic, and subeconomic commodities. To reflect varying degrees of geologic certainty, these economic divisions can be subdivided into measured, indicated, and inferred.

MEASURED.--Quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes; grade and (or) quality are computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely and the geologic character is so well defined that size, shape, depth, and mineral content of the resources are well established.

INDICATED.--Quantity and grade and (or) quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough for continuity between points of observation to be assumed.

INFERRED.--Estimates are based on assumed continuity beyond measured and (or) indicated resources for which there is geologic evidence. There may be no samples or measurements.

RESERVE BASE.--That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth.

RESERVES.--That part of the reserve base which could be economically 1/ extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as "extraneous reserves" and "recoverable reserves" are redundant and are not a part of this classification system.

1/ In this report, reserves are expected to yield at least a 20% rate of return.

APPENDIX A.--RESOURCE/RESERVE DEFINITIONS

(From U.S. Geological Survey Circular 831, 1980)

RESOURCE.--A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

IDENTIFIED RESOURCES.--Resources whose location, grade, quality, and quantity are known or estimated from specific geologic evidence. Identified resources include economic, marginally economic, and subeconomic components. To reflect varying degrees of geologic certainty, these economic divisions can be subdivided into measured, indicated, and inferred.

MEASURED.--Quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes; grade and (or) quality are computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely and the geologic character is so well defined that size, shape, depth, and mineral content of the resource are well established.

INDICATED.--Quantity and grade and (or) quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough for continuity between points of observation to be assumed.

INFERRED.--Estimates are based on an assumed continuity beyond measured and (or) indicated resources for which there is geologic evidence. There may be no samples or measurements.

RESERVE BASE.--That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth.

RESERVES.--That part of the reserve base which could be economically ^{1/} extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system.

^{1/} In this report, reserves are expected to yield at least a 20% rate of return.

MARGINAL RESERVES.--That part of the reserve base which, at the time of determination, borders on being economically producible. 2/

ECONOMIC.--This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

SUBECONOMIC RESOURCES.--The part of identified resources that does not meet the economic criteria 3/ of reserves and marginal reserves.

OCCURRENCES 4/.--Not defined in U.S. Geological Survey Circular 831, 1980.

2/ In this report, marginal reserves are expected to yield less than a 20% rate of return, but to return at least the production expenditures.

3/ In this report, subeconomic resources are expected to return at least 20% but less than 100% of production expenditures.

4/ In this report, an occurrence is expected to return less than 20% of expenditures necessary to produce the commodity.

MARGINAL RESERVE—The part of the reserve base which, at the time of definition, bears no being economically profitable. 2/

ECONOMIC—This term implies that profitable utilization or production of the reserve base has been established, and that the reserve base is being utilized in a profitable manner. 3/

RESERVE BASE—The part of identified resources that does not bear the economic criteria 2/ of reserve and marginal reserve.

CONCLUSIONS—For further in U.S. Geological Survey Circular 11, 1950.

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- 2/ In this report, marginal reserves are expected to yield less than a 10% rate of return, but to return at least the production expenditures.
 - 3/ In this report, economic resources are expected to return at least 10% but less than 100% of production expenditures.
 - 4/ In this report, an occurrence is expected to return less than 10% of expenditures necessary to produce the commodity.

MARGINAL RESERVES.--That part of the reserve base which, at the time of determination, borders on being economically producible. 2/

ECONOMIC.--This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

SUBECONOMIC RESOURCES.--The part of identified resources that does not meet the economic criteria 3/ of reserves and marginal reserves.

OCCURRENCES 4/.--Not defined in U.S. Geological Survey Circular 831, 1980.

2/ In this report, marginal reserves are expected to yield less than a 20% rate of return, but to return at least the production expenditures.

3/ In this report, subeconomic resources are expected to return at least 20% but less than 100% of production expenditures.

4/ In this report, an occurrence is expected to return less than 20% of expenditures necessary to produce the commodity.

APPENDIX B--PRELIMINARY CHARACTERIZATION AND CHEMICAL ANALYSIS OF DIATOMITE SAMPLES

Table B1--Preliminary characterization of diatomite located from the Great Basin diatomite deposit

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Locality	Geology, description of diatomite, and (where available) microscopic description	Sample weight (g)	Length (cm)	Width (cm)	Thickness (cm)	Specific gravity (g/cm ³)	Hardness (Mohs)	Fracture	Color	Streak	Diaphaneity	Notes
1	Quartzite, diatomite (not very siliceous), very fragmentary, small, very irregular, 200-300 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray
2	Quartzite, diatomite (not very siliceous), very fragmentary, fine, plate irregular, 100-200 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray
3	Small nodules, irregular, siliceous, some white, some gray, some black, 100-200 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray
4	Quartzite, diatomite, small, irregular, some white, some plate irregular, 100-200 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray
5	Small, non-siliceous, irregular, some white, some gray, some black, 100-200 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray
6	Quartzite, diatomite, some irregular, some white, some plate irregular, 100-200 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray
7	Quartzite, diatomite, some irregular, some white, some plate irregular, 100-200 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray
8	Quartzite, diatomite, some irregular, some white, some plate irregular, 100-200 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray
9	Quartzite, diatomite, some irregular, some white, some plate irregular, 100-200 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray
10	Quartzite, diatomite, some irregular, some white, some plate irregular, 100-200 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray
11	Quartzite, diatomite, some irregular, some white, some plate irregular, 100-200 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray
12	Quartzite, diatomite, some irregular, some white, some plate irregular, 100-200 grains, clay, granular.	100	10	10	10	2.6	5-6	Conchoidal	Light gray	Light gray	Translucent	Light gray

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Table B-1--Preliminary characterization of diatomite samples from the Clover Creek diatomite deposit

(NAp, not applicable)

Sample no. (fig. 3)	Microscopic examination (genera, condition of diatoms, and contaminants)	Sample type	Sample length (ft)	Crude 4/ consolidation	Crude 4/ color	Moisture 5/ (%)	LOI 6/ (%)	Ignited 7/ consolidation	Ignited 7/ color
1/ 1	Epithemia, Navicula (not many diatoms), very fragmented. Much plate material; 20%-25% quartz, clay, carbonates.	Point	NAp	Semi-soft	Dark beige	22.8	3.3	Soft	Dark red
1/ 2	Navicula, Epithemia (not many diatoms), very fragmented. Some plate material; 20%-25% quartz, clay, carbonates.	do---	NAp	Semi-hard	Beige	30.6	5.5	do-----	Dark orange
1/ 3	Small Melosira, Actinopterychus, Navicula, some whole. Some plate material; 10%-15% quartz, clay, carbonates.	Chip	3.0	Semi-hard	Off-white	15.6	7.6	do-----	Orange
1/ 4	Epithemia, Navicula, small Melosira, some whole. Some plate material; 5%-10% quartz, clay.	do---	3.0	Semi-soft	Light beige	16.3	4.1	Semi-soft	Dark orange
1/ 5	Small and medium Melosira, Navicula, Actinopterychus, Epithemia, many whole. Some plate material; 10%-15% quartz, clay.	do---	3.0	do-----	do-----	16.9	3.9	do-----	Orange
1/ 6	Navicula, Epithemia, medium Melosira, some whole. Some plate material; 5%-10% quartz, clay.	do---	3.0	do-----	do-----	10.8	3.9	Soft	do-----
1/ 7	Epithemia, Navicula, medium Melosira, Actinopterychus; some whole. Some plate material; 10%-15% quartz, clay.	do---	3.0	Soft	Off-white	16.9	3.5	do-----	Light orange
1/ 8	Epithemia, Navicula, medium Melosira, Actinopterychus; some whole. Some plate material; 5%-10% quartz, clay.	do---	3.0	do-----	do-----	15.6	3.6	do-----	do-----
9	Melosira, Epithemia, Synedra, and some spicules; some whole. Contains 20% carbonate and 5% clay.	do---	1.3	Not analyzed due to contaminants.					
10	Epithemia and Melosira, fragmented. Contains 10% carbonate.	do---	2.3	do-----					
11	Mixture of Navicula, Epithemia, Actinopterychus, Melosira, Synedra and others; diatoms fragmented. Some sponge spicules; much plate material; 10%-15% quartz.	do---	5.0	Semi-hard	Beige	29.1	4.1	do-----	Dark orange
12	Same diatoms as 11, diatoms fragmented. Some sponge spicules, some plate material; 10%-15% quartz.	do----	5.0	do-----	do-----	24.0	4.0	do-----	Orange

Table B-1--Preliminary characterization of diatomite samples from the Clover Creek diatomite deposit--Continued

Sample no. (fig. 3)	Microscopic examination (genera, condition of diatoms, and contaminants)	Sample type	Sample length (ft)	Crude 4/ consolidation	Crude 4/ color	Moisture 5/ (%)	LOI 6/ (%)	Ignited 7/ consolidation	Ignited 7/ color
13	Melosira, Epithemia, Fragilaria, Stephanodiscus, and Cymbella; some whole. Contains 30% carbonate.	Chip	5.0	Not analyzed due to contaminants					
14	Epithemia, Cymbella, Synedra, Melosira, Fragilaria, Cyclotella; fragmented. Contains 50% carbonate.	do---	5.0	do-----					
15	Epithemia, Cocconeis, Melosira, Fragilaria, Stephanodiscus; some whole. Contains 30%-40% carbonate.	do---	5.0	do-----					
16	Melosira, Epithemia, Navicula, Fragilaria; fragmented. Contains 50%-70% gypsum with some quartz and carbonate.	do---	5.0	do-----					
17	Epithemia, Melosira, Cymbella, Cyclotella, Fragilaria; some whole. Contains 50% carbonate.	do---	5.0	do-----					
18	Melosira, Epithemia, Cyclotella, Synedra; some whole. Contains 20% carbonate and 10% gypsum.	do---	5.0	do-----					
19	Fragilaria, Epithemia, Melosira, Cocconeis, Cymbella, Synedra; fragmented. Contains 30%-50% carbonate and 5%-10% chalcedony.	do---	5.0	do-----					
20	Epithemia, Melosira, Fragilaria, Cymbella, Ambistria Navicula, Cocconeis; some whole. Contains 30% carbonate, 5% gypsum, and some clay.	do---	5.0	do-----					
21	Epithemia, Melosira, Fragilaria, Coscinodiscus, Cymbella, Cocconeis; fragmented. Contains 40% carbonate with some clay and gypsum.	do---	5.0	do-----					
1/ 22	Mixture of Actinopterychus, small Melosira, and Epithemia, some whole. Some plate material; 10%-15% quartz, clay.	Point	NAp	Semi-hard	Beige	31.5	4.2	Soft	Orange
1/ 23	Large Melosira, Navicula, Epithemia, some whole. Some plate material; 10%-15% quartz, clay.	Chip	3.0	Semi-soft	Off-white	28.3	5.0	do-----	Beige
1/ 24	Navicula, Epithemia, Actinopterychus, medium Melosira, some whole. Some plate material; 15%-20% quartz, clay.	do----	3.0	do-----	Light beige	24.9	4.3	do-----	Dark beige
1/ 25	Epithemia, Navicula, Actinopterychus, some whole. Much plate material; 10%-15% quartz, clay.	do----	3.0	do-----	do-----	17.9	4.4	do-----	Light orange
1/ 26	Small Melosira, Actinopterychus, Epithemia, many whole. Much plate material; 20%-25% carbonates, clay, quartz.	Point	NAp	Semi-hard	Beige	26.9	14.7	do-----	Light beige
1/ 27	Small Melosira, Actinopterychus, many whole. Some plate material; 20%-25% carbonates, clay, quartz.	do----	NAp	Soft	Dark beige	34.5	14.1	do-----	Beige

Table B-1--Preliminary characterization of diatomite samples from the Clover Creek diatomite deposit--Continued

Sample no. (fig. 3)	Microscopic examination (genera, condition of diatoms, and contaminants)	Sample type	Sample length (ft)	Crude 4/ consolidation	Crude 4/ color	Moisture 5/ (%)	LOI 6/ (%)	Ignited 7/ consolidation	Ignited 7/ color
1/ 28	Small <i>Melosira</i> , <i>Actinoptychus</i> , many whole. Some plate material; 20%-25% carbonates, clay, quartz.	Point	NAP	Soft	Dark beige	25.5	13.1	Soft	Beige
29	A mixture of <i>Navicula</i> , <i>Epithemia</i> , <i>Melosira</i> , <i>Fragilaria</i> , <i>Actinoptychus</i> , and other diatoms in minor amounts. Fragmented structure, some sponge spicules, much plate material; 10%-15% quartz and clay.	do----	NAP	Semi-soft	Beige	46.7	4.9	do-----	Orange
3/ 30	Same diatoms as 29. Many whole diatoms, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	NAP	Soft	do-----	35.4	4.3	do-----	do-----
31	Mixture of <i>Navicula</i> , <i>Epithemia</i> , <i>Melosira</i> , <i>Fragilaria</i> , <i>Synedra</i> , and others in minor amounts. Some whole diatoms, some sponge spicules, some plate material; 5%-10% quartz.	do----	NAP	Semi-soft	do-----	41.6	3.7	do-----	do-----
32	Same diatoms as 31. Some whole diatoms, some sponge spicules, some plate material; 10%-15% quartz.	do----	NAP	Soft	do-----	38.2	3.4	do-----	do-----
33	Same diatoms as 31. Some whole diatoms, some sponge spicules, some plate material; 10%-15% quartz.	do----	NAP	Semi-soft	do-----	42.2	3.8	do-----	do-----
34	Mixture of <i>Actinoptychus</i> , <i>Navicula</i> , <i>Epithemia</i> , <i>Fragilaria</i> , and <i>Melosira</i> plus others. Some whole diatoms, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	NAP	do-----	do-----	43.5	4.3	do-----	do-----
35	Mixture of <i>Melosira</i> , <i>Navicula</i> , <i>Epithemia</i> , <i>Actinoptychus</i> , and <i>Fragilaria</i> plus others. Some whole diatoms, some sponge spicules, some plate material; 15%-20% quartz and clay.	do----	NAP	do-----	do-----	43.1	4.1	do-----	do-----
36	Mixture of <i>Epithemia</i> , <i>Navicula</i> , <i>Fragilaria</i> , <i>Synedra</i> , and <i>Melosira</i> plus others; some whole diatoms. Some sponge spicules, some plate material; 10%-15% quartz.	do----	NAP	do-----	Light beige	48.7	3.7	do-----	Light orange
37	Mixture of <i>Navicula</i> , <i>Epithemia</i> , <i>Melosira</i> , and <i>Fragilaria</i> plus others, some whole diatoms. Some sponge spicules, much plate material; 15%-20% quartz and clay.	do----	NAP	do-----	Beige	43.8	4.2	do-----	Dark red
38	Mixture of <i>Actinoptychus</i> , <i>Melosira</i> , <i>Navicula</i> , <i>Epithemia</i> , and <i>Synedra</i> plus others, some whole diatoms. Some sponge spicules, much plate material; 15%-20% quartz and clay.	do----	NAP	do-----	do-----	43.6	3.9	do-----	Orange
39	Same diatoms as 38. Some whole diatoms, some sponge spicules; some plate material; 10%-15% quartz and clay.	do----	NAP	Soft	Light beige	44.0	3.9	do-----	do-----

Table B-1--Preliminary characterization of diatomite samples from the Clover Creek diatomite deposit--Continued

Sample no. (fig. 3)	Microscopic examination (genera, condition of diatoms, and contaminants)	Sample type	Sample length (ft)	Crude 4/ consolidation	Crude 4/ color	Moisture 5/ (%)	LOI 6/ (%)	Ignited 7/ consolidation	Ignited 7/ color
40	Mixture of Melosira, Navicula, and Epithemia plus others; some whole diatoms. Some sponge spicules, much plate material; 15%-20% quartz and clay.	Point	NAP	Soft	Light beige	43.9	4.7	Soft	Dark orange
41	Mixture of Navicula, Epithemia, Actinopterychus, and Melosira, some whole diatoms. Some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	NAP	Semi-soft	Beige	42.9	4.5	do---	Beige
1/ 42	Small and medium Melosira, many whole. Some plate material; 5%-10% quartz.	Chip	3.0	Semi-hard	do-----	11.5	4.7	Semi-soft	Dark pink
1/ 43	Epithemia, Navicula, very fragmented. Much plate material; 10%-15% quartz, clay.	do----	1.0	do-----	do-----	10.9	4.3	do----	Dark red
1/ 44	Navicula, Synedra, Epithemia; small Melosira, Fragilaria, fragmented. Some plate material; 10%-15% quartz, clay.	do----	2.5	Semi-soft	do-----	10.9	5.2	do----	Dark orange
1/ 45	Navicula, Epithemia, Actinopterychus; some whole. Some plate material, some sponge spicules; 10%-15% quartz, clay.	do----	1.0	do-----	Light beige	12.8	3.8	Soft	Light orange
1/ 46	Actinopterychus, Epithemia, Navicula; some whole. Some plate material; 5%-10% quartz, clay.	do----	3.0	do-----	do-----	13.6	3.8	do----	do-----
1/ 47	Actinopterychus, Epithemia, Navicula; some whole. Some plate material; 5%-10% quartz, clay.	Point	NAP	Soft	do-----	31.7	4.0	do----	do-----
1/ 48	Actinopterychus, Epithemia, Navicula; many whole. Some plate material; 10%-15% quartz, clay.	Chip	2.5	Semi-soft	do-----	11.4	4.2	Semi-soft	do-----
1/ 49	Navicula, Epithemia, Actinopterychus, Fragilaria; some whole. Some plate material some sponge spicules; 5%-10% quartz, clay.	do----	3.0	do-----	do-----	19.7	4.1	Soft	do-----
3/ 50	Mixture of Navicula, Epithemia, Fragilaria, Actinopterychus, Melosira, and Synedra plus others, many whole diatoms. Some sponge spicules, some plate material; 10%-15% quartz and clay.	Point	NAP	Soft	do-----	35.5	5.0	do----	Orange
1/ 51	Navicula, Epithemia, very fragmented. Much plate material; 10%-15% quartz, clay.	Chip	3.0	Semi-hard	Beige	35.7	5.9	Semi-soft	Dark orange
1/ 52	Navicula, Epithemia; very fragmented. Much plate material; 10%-15% clay, quartz.	do----	2.5	do-----	do-----	44.2	4.9	do-----	Orange
1/ 53	Actinopterychus, Navicula, small Melosira; fragmented. Some plate material; 5%-10% quartz, clay.	Point	NAP	do-----	do-----	38.6	5.7	Soft	do-----

Table B-1--Preliminary characterization of diatomite samples from the Clover Creek diatomite deposit--Continued

Sample no. (fig. 3)	Microscopic examination (genera, condition of diatoms, and contaminants)	Sample type	Sample length (ft)	Crude 4/ consolidation	Crude 4/ color	Moisture 5/ (%)	LOI 6/ (%)	Ignited 7/ consolidation	Ignited 7/ color
2/ 54	Same diatoms as 50. Fragmented diatoms, some sponge spicules, some plate material; 10%-15% quartz.	Chip	4.6	Soft	Beige----	36.9	5.4	Soft	Dark orange
2/ 55	Same diatoms as 50. Many whole diatoms, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	4.9	do-----	do-----	30.5	4.3	do-----	Orange
2/ 56	Same diatoms as 50. Some whole diatoms, some sponge spicules, some plate material; 15%-20% quartz and clay.	do----	5.0	do-----	do-----	39.1	4.3	do-----	do-----
2/ 57	Mixture of Melosira, Actinoptychus, Navicula, Epithemia, and Synedra plus others. Many whole diatoms, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	5.2	do-----	Light beige	23.1	3.9	do-----	do-----
2/ 58	Same diatoms as 57. Many whole diatoms, some sponge spicules, much plate material; 10%-15% quartz.	do----	4.9	do-----	do-----	22.2	4.4	do-----	do-----
2/ 59	Same diatoms as 57. Some whole diatoms, some sponge spicules, much plate material; 5%-10% quartz.	do----	4.9	do-----	do-----	19.2	4.2	do-----	Light orange
2/ 60	Mixture of Navicula, Epithemia, and Melosira plus others. Diatoms fragmented, many sponge spicules, much plate material; 15%-20% quartz and clay.	do----	4.9	Semi-soft	Beige	27.5	5.1	do-----	Dark red
2/ 61	Same diatoms as 57. Diatoms fragmented, many sponge spicules, much plate material; 15%-20% quartz and clay.	do----	4.9	Soft	Light beige	23.3	4.7	do-----	Orange
2/ 62	Same diatoms as 57. Some whole diatoms, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	4.9	do-----	do-----	28.6	4.3	do-----	do-----
2/ 63	Mixture of Navicula, Epithemia, and Melosira plus others. Diatoms fragmented, some sponge spicules, much plate material; 15%-20% quartz and clay.	do----	4.9	do-----	do-----	30.1	5.0	do-----	do-----
2/ 64	Mostly small Melosira with some Navicula and Epithemia plus others. Many whole diatoms, some sponge spicules, some plate material; 10%-15% quartz.	do----	4.9	do-----	do-----	21.2	4.5	do-----	do-----
2/ 65	Same diatoms as 64, plus Actinoptychus. Many whole diatoms, some plate material; 15%-20% quartz and clay.	do----	4.9	do-----	do-----	18.7	4.2	do-----	do-----
2/ 66	Same diatoms as 64. Many whole diatoms, much plate material; 15%-20% quartz and clay.	do----	3.7	do-----	do-----	17.6	4.5	do-----	do-----
2/ 67	Mixture of Navicula, Epithemia, and Synedra. Few diatoms which are very fragmented. Some sponge spicules, much plate material; 25%-30% quartz and clay.	do----	2.4	Semi-soft	Beige	13.4	3.7	do-----	Dark red

Table B-1--Preliminary characterization of diatomite samples from the Clover Creek diatomite deposit--Continued

Sample no. (fig. 3)	Microscopic examination (genera, condition of diatoms, and contaminants)	Sample type	Sample length (ft)	Crude 4/ consolidation	Crude 4/ color	Moisture 5/ (%)	LOI 6/ (%)	Ignited 7/ consolidation	Ignited 7/ color
2/ 68	Mixture of Navicula, Epithemia, Synedra, Fragilaria, and Actinoptychus plus others. Diatoms fragmented, some sponge spicules, some plate material; 10%-15% quartz and clay.	Chip--	3.7	Soft	Light beige	18.4	6.5	Soft	Light orange
2/ 69	Same diatoms as 68. Some whole diatoms, some sponge spicules, some plate material; 5%-10% quartz and clay.	do----	4.9	do-----	do-----	26.3	4.8	do-----	do-----
2/ 70	Same diatoms as 68. Diatoms fragmented, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	4.4	do-----	do-----	23.3	5.7	do-----	do-----
2/ 71	Same diatoms as 68. Diatoms very fragmented, some sponge spicules, some plate material; 10%-15% quartz.	do----	4.1	do-----	do-----	32.8	5.6	do-----	Orange
2/ 72	Mixture of Actinoptychus, Melosira, and Navicula plus others. Some whole diatoms, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	5.1	Semi-soft	Beige	32.6	4.6	do-----	do-----
2/ 73	Mixture of Melosira, Navicula, and Epithemia plus others. Some whole diatoms, some sponge spicules, some plate material; 20%-25% quartz and clay.	do----	5.0	do-----	do-----	22.2	5.2	do-----	do-----
2/ 74	Same diatoms as 73. Some whole diatoms, some plate material; 20%-25% quartz and clay.	do----	3.8	do-----	do-----	26.8	4.7	do-----	do-----
2/ 75	Mixture of Navicula, Epithemia, Fragilaria, and Synedra plus others. Diatoms fragmented, some sponge spicules, much plate material; 5%-10% quartz.	do----	3.4	Soft	Light beige	26.2	4.4	do-----	do-----
2/ 76	Same diatoms as 75. Many whole diatoms, many sponge spicules, some plate material; 5%-10% quartz.	do----	5.1	do-----	do-----	25.1	4.8	do-----	do-----
2/ 77	Same diatoms as 75. Some whole diatoms, many sponge spicules, some plate material; 10%-15% quartz.	do----	5.1	do-----	do-----	24.2	5.3	do-----	Light orange
2/ 78	Same diatoms as 75 plus Actinoptychus. Some whole diatoms, some sponge spicules, some plate material; 15%-20% quartz and clay.	do----	5.1	do-----	do-----	22.0	4.4	do-----	do-----
2/ 79	Same diatoms as 75. Many whole diatoms, some sponge spicules, some plate material; 5%-10% quartz and clay.	do----	5.1	do-----	do-----	28.3	4.3	do----	do-----
2/ 80	Mixture of Navicula, Epithemia, and Synedra plus others. Few diatoms which are very fragmented, some sponge spicules, much plate material; 35%-40% quartz and clay.	do----	6.2	Semi-soft	Beige	15.9	4.0	do----	Dark red
2/ 81	Same diatoms as 78. Some whole diatoms, some sponge spicules, much plate material; 10%-15% quartz and clay.	do----	5.1	Soft	Light beige	26.5	4.6	do----	Orange

Table B-1--Preliminary characterization of diatomite samples from the Clover Creek diatomite deposit--Continued

Sample no. (fig. 3)	Microscopic examination (genera, condition of diatoms, and contaminants)	Sample type	Sample length (ft)	Crude 4/ consolidation	Crude 4/ color	Moisture 5/ (%)	LOI 6/ (%)	Ignited 7/ consolidation	Ignited 7/ color
2/ 82	Mostly small <i>Melosira</i> with <i>Navicula</i> , <i>Epithemia</i> , and others. Many whole diatoms, some plate material; 10%-15% quartz and clay.	Chip--	5.1	Soft	Light beige	31.1	4.3	Soft	Orange
2/ 83	Same diatoms as 78 plus <i>Melosira</i> . Some whole diatoms, some sponge spicules, some plate material; 5%-10% quartz.	do----	5.0	Semi-soft	do-----	38.1	4.7	do----	do-----
2/ 84	Same diatoms as 78. Some whole diatoms, some sponge spicules, much plate material; 10%-15% quartz.	do----	5.1	Soft	do-----	31.9	4.3	do----	do-----
2/ 85	Same diatoms as 78. Diatoms fragmented, some sponge spicules, much plate material; 15%-20% quartz.	do----	5.1	Semi-soft	do-----	32.5	4.8	do----	do-----
2/ 86	Same diatoms as 78. Some whole diatoms, some sponge spicules, some plate material; 10%-15% quartz.	do----	5.1	Soft	do-----	31.6	5.0	do----	Dark orange
2/ 87	Same diatoms as 78. Diatoms fragmented, some sponge spicules, some plate material; 10%-15% quartz.	do----	5.1	do-----	Beige	24.7	4.7	do----	do-----
2/ 88	Mixture of <i>Navicula</i> , <i>Epithemia</i> , <i>Synedra</i> , <i>Fragilaria</i> , <i>Actinoptychus</i> , and <i>Melosira</i> plus others. Many whole diatoms, some sponge spicules, some plate material; 5%-10% quartz.	do----	5.1	do-----	Light beige	34.8	4.5	do----	Orange
2/ 89	Same diatoms as 88. Some whole diatoms, some sponge spicules, much plate material; 10%-15% quartz.	do----	5.1	do-----	do-----	36.1	5.9	do----	do-----
2/ 90	Same diatoms as 88. Some whole diatoms, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	5.1	do-----	do-----	27.4	4.5	do----	do-----
2/ 91	Same diatoms as 88. Many whole diatoms, some sponge spicules, some plate material; 15%-20% quartz and clay.	do----	5.1	do-----	do-----	20.7	4.5	do----	do-----
2/ 92	Same diatoms as 88. Some whole diatoms, some sponge spicules, much plate material; 10%-15% quartz and clay.	do----	5.1	do-----	do-----	29.1	4.6	do----	do-----
2/ 93	Same diatoms as 88. Diatoms fragmented, some sponge spicules, some plate material; 5%-10% quartz.	do----	5.1	do-----	do-----	36.9	4.2	do-----	do-----
2/ 94	Same diatoms as 88. Some whole diatoms, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	5.0	do-----	do-----	41.2	4.6	do-----	do-----
2/ 95	Same diatoms as 88. Diatoms fragmented, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	5.0	do-----	Beige	39.6	5.1	do-----	do-----
2/ 96	Same diatoms as 88. Some whole diatoms, some sponge spicules, much plate material; 15%-20% quartz and clay.	do----	5.0	do-----	do-----	33.3	3.9	do-----	do-----

Table B-1--Preliminary characterization of diatomite samples from the Clover Creek diatomite deposit--Continued

Sample no. (fig. 3)	Microscopic examination (genera, condition of diatoms, and contaminants)	Sample type	Sample length (ft)	Crude 4/ consolidation	Crude 4/ color	Moisture 5/ (%)	LOI 6/ (%)	Ignited 7/ consolidation	Ignited 7/ color
2/ 97	Same diatoms as 88. Some whole diatoms, some sponge spicules, some plate material; 10%-15% quartz and clay.	Chip--	5.0	Soft	Beige	35.9	3.5	Soft	Light orange
2/ 98	Same diatoms as 88. Some whole diatoms, some sponge spicules, much plate material; 10%-15% quartz.	do----	5.0	do-----	do-----	19.5	3.8	do-----	do-----
2/ 99	Same diatoms as 88. Diatoms fragmented, some sponge spicules, some plate material; 15%-20% quartz and clay.	do----	4.0	do-----	do-----	39.2	4.2	do-----	Orange
2/ 100	Same diatoms as 88. Diatoms very fragmented, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	4.9	do-----	do-----	36.1	4.4	do-----	do-----
2/ 101	Same diatoms as 88. Diatoms very fragmented, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	5.1	do-----	do-----	29.6	4.6	do-----	do-----
2/ 102	Same diatoms as 88. Diatoms fragmented, some sponge spicules, much plate material; 10%-15% quartz.	do----	5.1	Semi-soft	do-----	36.5	4.7	do-----	do-----
2/ 103	Mixture of mainly Actinopterychus with some Navicula, Epithemia, Synedra, Melosira, and others. Many whole diatoms, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	5.1	do-----	Light beige	19.8	3.7	do-----	do-----
2/ 104	Same diatoms as 103. Some whole diatoms, some sponge spicules, much plate material; 15%-20% quartz and clay.	do----	5.1	do-----	do-----	21.3	3.5	do-----	Light orange
2/ 105	Same diatoms as 103. Some whole diatoms, some sponge spicules, some plate material; 10%-15% quartz and clay.	do----	5.1	Soft	do-----	18.2	3.9	do-----	do-----
2/ 106	Mixture of mainly small Melosira with some Actinopterychus, Epithemia, Navicula, Synedra, and others. Many whole diatoms, some sponge spicules, some plate material; 15%-20% quartz and clay.	do----	5.0	Semi-soft	do-----	35.0	4.9	do-----	do-----
2/ 107	Same diatoms as 106. Many whole diatoms, some sponge spicules, some plate material; 25%-30% quartz and clay.	Point	NAp	do-----	Beige	11.6	10.5	do-----	Beige
2/ 108	Same diatoms as 106. Some whole diatoms, some sponge spicules, much plate material; 20%-25% quartz and clay.	Chip	5.0	do-----	Dark beige	13.4	9.3	do-----	do-----
1/ 109	Navicula, Epithemia (not many diatoms). Very fragmented, some plate material; 15%-20% quartz, carbonates, clay.	Point	NAp	Semi-hard	Beige	8.1	10.9	Semi-soft	Light orange
1/ 110	Actinopterychus, Navicula, Epithemia. Many whole, some plate material; 10%-15% quartz, clay.	Chip	3.0	do-----	do-----	9.0	4.3	do-----	Orange

Table B-1--Preliminary characterization of diatomite samples from the Clover Creek diatomite deposit--Continued

Sample no. (fig. 3)	Microscopic examination (genera, condition of diatoms, and contaminants)	Sample type	Sample length (ft)	Crude 4/ consolidation	Crude 4/ color	Moisture 5/ (%)	LOI 6/ (%)	Ignited 7/ consolidation	Ignited 7/ color
1/ 111	Epithemia, Navicula, Actinopterychus, small Melosira. Some whole, much plate material; 5%-10% quartz, clay.	Chip--	2.5	Semi-hard	Light beige	16.9	4.9	Soft	Light orange
1/ 112	Epithemia, Navicula, Actinopterychus. Fragmented, much plate material; 5%-10% quartz, clay.	do----	2.0	Semi-soft	do-----	29.4	4.9	do-----	Pink
1/ 113	Small and medium Melosira, Navicula. Some whole, some plate material; 15%-20% clay, quartz.	do----	3.0	Semi-hard	do-----	26.1	6.0	do-----	Dark beige
1/ 114	Large Melosira, Navicula, Epithemia. Some whole, some plate material; 15%-20% clay, quartz.	Point	NAp	do-----	Beige	14.5	5.1	Semi-soft	Dark orange
115	Mixture of Actinopterychus, Navicula, Epithemia, and Melosira plus others. Many whole diatoms, some sponge spicules, some plate material; 15%-20% quartz and clay.	do----	NAp	Semi-soft	do-----	38.4	5.3	Soft	Dark beige

1/ Samples taken by WGM, Inc., Alaska, and analyzed by Manville.

2/ Samples submitted to USBM Reno Laboratory for chemical analyses; see table B-2.

3/ Samples resubmitted to Manville for detailed characterization; see Table 2 and Appendix C.

4/ Crude: condition prior to ignition.

5/ Moisture %: amount of water lost upon heating a sample to 100°C.

6/ LOI: loss on ignition; the loss in weight which results from heating a sample to 1,000°C - includes organic materials.

7/ Ignited: condition after ignition.

Table B-2--Chemical analyses of samples 54-108 from the
Clover Creek diatomite deposit

No. (fig. 3)	Chemical analyses								
	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	TiO ₂ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	LOI 1/ %
54	69.2	10.1	3.4	0.43	1.7	2.5	0.96	0.53	11.78
55	65.7	8.4	2.9	.37	1.4	1.7	.75	.44	18.81
56	67.6	6.6	2.5	.31	1.9	1.7	.62	.31	17.27
57	78.1	7.3	2.6	.32	1.1	1.3	.73	.37	7.74
58	75.5	9.5	3.3	.42	1.3	1.8	.81	.43	8.23
59	76.6	8.2	2.9	.37	1.2	1.6	.76	.42	9.08
60	65.4	13.0	4.8	.60	1.8	2.8	1.00	.80	10.44
61	71.0	11.3	4.2	.49	1.4	1.9	.93	.67	10.02
62	72.5	10.1	3.5	.47	1.2	1.6	.71	.43	11.44
63	73.0	10.5	3.3	.48	1.2	1.7	.73	.42	9.90
64	70.6	10.4	3.8	.44	1.3	2.0	.92	.55	9.40
65	73.1	11.4	3.9	.47	1.2	1.9	.98	.61	7.34
66	73.5	10.7	3.8	.46	1.2	2.0	.94	.63	7.50
67	68.9	14.0	4.6	.63	2.0	1.8	1.7	1.1	5.94
68	74.8	9.3	2.8	.42	2.1	1.9	.51	.35	9.77
69	71.3	9.5	3.0	.43	1.3	2.4	.37	.94	8.67
70	67.0	13.2	3.8	.58	2.0	2.0	.69	.30	10.79
71	67.6	10.0	3.1	.44	2.4	2.7	.42	1.00	9.92
72	72.0	9.6	3.3	.42	2.0	1.8	.71	.52	11.23
73	71.2	12.3	4.2	.52	1.6	1.9	.91	.75	8.56
74	72.6	12.7	4.3	.53	1.5	1.9	.93	.69	8.09
75	77.8	7.9	2.7	.35	1.6	1.8	.45	.38	9.81
76	77.8	7.3	2.6	.33	1.1	1.8	.45	.32	8.99
77	76.9	7.6	2.6	.33	1.9	2.1	.49	.35	9.05
78	75.4	8.3	2.7	.34	1.3	5.2	.70	.95	8.55
79	76.4	7.4	2.6	.30	1.3	4.9	.63	.84	8.82
80	66.7	12.2	4.8	.54	1.8	6.0	1.3	1.9	8.08
81	73.6	8.7	3.0	.35	1.3	5.0	.55	.82	9.97
82	74.4	8.8	3.0	.36	1.5	4.8	.74	1.1	8.65
83	75.6	8.5	2.8	.35	1.3	4.5	.71	.97	9.01
84	72.2	9.9	3.2	.41	1.8	4.2	1.00	1.3	8.98
85	69.8	9.7	4.4	.44	1.8	5.3	1.9	1.2	9.27
86	71.4	9.5	4.1	.44	1.4	4.9	.74	1.2	9.32
87	71.8	9.4	3.7	.46	1.4	4.8	.76	1.1	10.17
88	66.9	8.9	3.3	.39	1.2	5.0	.71	1.00	17.03
89	68.4	9.5	3.5	.40	1.7	5.5	1.1	.94	12.91
90	77.0	7.3	2.6	.30	1.5	4.4	.83	.92	8.35
91	76.9	7.1	2.5	.30	1.6	4.8	.83	.89	8.52
92	76.4	6.9	2.6	.28	1.5	5.0	.72	.88	9.19
93	75.2	6.7	2.2	.28	3.3	5.0	.71	.84	8.07
94	74.3	7.1	2.2	.30	2.3	6.3	.68	.90	8.89
95	67.0	9.0	3.4	.36	2.5	6.0	1.2	1.2	13.23
96	73.4	9.7	3.0	.39	1.1	3.9	1.1	1.00	8.41
97	75.1	7.4	2.5	.31	1.00	3.9	1.00	1.00	11.19

Table B-2--Chemical analyses of samples 54-108 from the
Clover Creek diatomite deposit--Continued

No. (fig. 3)	Chemical analyses									LOI ^{1/} %
	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	TiO ₂ %	CaO %	MgO %	Na ₂ O %	K ₂ O %		
98	77.1	7.6	2.6	.33	1.4	4.6	1.1	1.00	8.07	
99	75.4	7.1	2.4	.29	1.2	5.7	1.3	.95	8.99	
100	71.2	10.2	3.3	.42	1.6	6.3	1.1	1.2	8.83	
101	70.5	11.2	3.5	.45	1.4	6.0	1.1	1.1	8.68	
102	73.7	9.5	3.1	.42	1.1	5.3	1.1	1.00	8.88	
103	76.7	8.8	2.6	.34	1.00	4.4	.98	1.3	7.76	
104	77.6	7.0	2.5	.27	1.2	5.6	.81	.96	7.77	
105	78.9	5.7	2.2	.23	1.8	5.2	.66	.77	8.51	
106	76.1	5.7	2.0	.23	2.8	6.1	.53	.75	9.11	
107	64.6	10.1	3.4	.42	6.3	3.7	1.00	1.4	11.41	
108	59.6	7.0	2.4	.27	10.3	4.7	1.4	1.00	15.64	

Sample is then used to measure the flux-calculated 2/ samples for testing. The milled material is again classified into separator, cyclone, and baghouse fractions. The separator fraction is recycled until it appears too contaminated or glassy to warrant further recycling. Acceptable diatomite will achieve 100 separator fraction and 90% cyclone fraction after three passes.

Loss Weight

The stuffed bulk density of diatomite samples is determined by gently screening a natural or flux-calculated matter into a known volume can and weighing the contents. Natural products of good quality will generally be between 5 and 10 lb/ft³. Although loose weight is not a highly significant property of flux-calculated filler slips, values in the 10 to 15 lb/ft³ range should be expected.

Wet Density

A given weight of the natural product is dispersed in water and centrifuged in a calibrated can. The wet density determines the caking properties in filtration applications. Natural products of good quality weigh between 14 and 22 lb/ft³.

1/ Natural diatomite: a dried sample of crude mill-run diatomite.

2/ Flux-calculated: a dried sample of natural diatomite is heated to an optimum temperature and silica ash (SiO₂) is added.

1/ LOI: Loss on ignition; the loss in weight which results from heating a sample to 1000°C - includes organic materials and residual water.

APPENDIX C--MILLING, CLASSIFICATION, PHYSICAL, AND CHEMICAL
SPECIFICATIONS FOR PROCESSED NATURAL AND FLUX-CALCINED
DIATOMITE

(data from Manville Service Corporation, 1985)

Milling and Classification

The dried natural 1/ diatomite sample is simultaneously milled and air classified. The milling is gentle enough to de-aggregate the sample without excessive destruction of diatom structure. The classifiers air-separate the milled material into three fractions: (a) a very coarse separator fraction, (b) an intermediate coarseness cyclone fraction, and (c) a baghouse fraction.

High-grade samples milled and classified under standard conditions, with one or two recycles will yield about 10% separator fraction. High baghouse fractions (greater than about 20%) would indicate excessive milling or undesirable fine diatom structure.

The same unit used for milling and classification of the natural sample is then used to prepare the flux-calcined 2/ samples for testing; the milled material is again air classified into separator, cyclone, and baghouse fractions. The separator fraction is recycled until it appears too contaminated or glassy to warrant further recycling. Desirable diatomite will achieve 10% separator fraction and 80% cyclone fraction after three passes.

Loose Weight

The fluffed bulk density of diatomite samples is determined by gently screening a natural or flux-calcined powder into a known volume cup and weighing the contents. Natural products of good quality will generally be between 5 and 10 lb/ft³. Although loose weight is not a highly significant property of flux-calcined filter aids, values in the 10 to 18 lb/ft³ range should be expected.

Wet Density

A given weight of the natural product is dispersed in water and centrifuged in a calibrated tube. The wet density determines the caking properties in filtration applications. Natural products of good quality weigh between 14 and 22 lb/ft³.

1/ Natural diatomite: a dried sample of crude (mill-run) diatomite.

2/ Flux-calcined: a dried sample of natural diatomite is heated to an optimum temperature and soda ash (Na₂CO₃) is added.

1. Introduction

2. Materials and Methods

The first series of experiments was designed to determine the effect of the concentration of the solution on the rate of reaction. The reaction was carried out in a closed system at a constant temperature of 25°C. The rate of reaction was determined by measuring the volume of gas evolved over a period of 10 minutes. The results are shown in Table I.

It was found that the rate of reaction increased with increasing concentration of the solution. This is in agreement with the theoretical prediction that the rate of reaction should be proportional to the concentration of the reactants.

The second series of experiments was designed to determine the effect of the temperature on the rate of reaction. The reaction was carried out in a closed system at a constant concentration of the solution. The rate of reaction was determined by measuring the volume of gas evolved over a period of 10 minutes. The results are shown in Table II.

3. Results and Discussion

The first series of experiments showed that the rate of reaction increased with increasing concentration of the solution. This is in agreement with the theoretical prediction that the rate of reaction should be proportional to the concentration of the reactants. The second series of experiments showed that the rate of reaction increased with increasing temperature. This is also in agreement with the theoretical prediction that the rate of reaction should be proportional to the temperature.

4. Conclusions

A series of experiments at the University of California, Berkeley, have shown that the rate of reaction increases with increasing concentration of the solution and with increasing temperature. This is in agreement with the theoretical predictions that the rate of reaction should be proportional to the concentration of the reactants and to the temperature.

1. The first series of experiments was designed to determine the effect of the concentration of the solution on the rate of reaction.

2. The second series of experiments was designed to determine the effect of the temperature on the rate of reaction.

The wet densities of desirable flux-calcined samples generally are between 12 and 20 lb/ft³. Good response to flux calcination should agglomerate fines and thereby decrease the products wet density relative to the natural wet density.

Screening

The percent residue of a given natural diatomite sample wet screened with spray washing, on a standard U.S. 325-mesh screen, indicates the de-aggregation of the diatoms. It is expected that the residue will be less than 10%.

Filtration applications require a compromise between the flow rate, which usually requires large particles to give faster flow rates, and having particles so large that they do not suspend or filter well. The residue on a U.S. 150-mesh screen should be less than 10% for most flux-calcined filter aids.

Blue Light

The blue light reflectance of a compressed diatomite powder surface compared to the percent of the reflectance of a precipitated magnesium oxide surface, as measured on a photovolt unit, is reported as the brightness of the sample. For many commercial applications, diatomite color is not important. Many commercial samples will have a brightness index of 60.

Brightness is not a major filtration quality property. However, desirable flux-calcined filter aids should have a brightness over 80, and brightnesses of greater than 80 are necessary for many filler applications, such as paint.

pH

The pH of a 10% slurry of sample and distilled water indicates the quantity of solubles present. Desirable natural diatomites will have pH's between 6 and 8. Flux-calcined samples usually show pH's between 8.5 and 10.5.

Resistivity

The resistivity (resistance to electrical current) of a filtered solution from a 10% slurry is measured with a standard cell and bridge and is reported in ohms per centimeter. Generally, desirable natural samples have resistivities greater than 3,000 ohm/cm. Low resistivities and neutral pH's indicate the presence of neutral salts.

Flux-calcined samples usually show resistivities of about 5,000 ohm/cm. Even with the addition of flux, some increase in resistivity is usually observed after calcination.

Flow Rate

The flow rate is established by the relative time it takes the diatomite to filter a given volume of dilute natural slurry of a set weight, at a constant vacuum. Generally, desirable natural samples will have a flow rate between 60 and 105 seconds. Generally, desirable flux-calcined samples will have a flow rate between 80 and 135 seconds. The flow rate times of natural and flux-calcined samples cannot be compared to each other.

Chemical Analyses

The chemical constituents of diatomite samples gives clues to the evaluation of impurities. Natural diatomite is usually greater than 80% SiO_2 after ignition. A desirable diatomite has an Fe_2O_3 content of less than 2% and an Al_2O_3 content of less than 5%. CaO contents are normally less than 1%, although in some cases higher levels can be tolerated, if solubilities are not increased excessively.

